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PARASITOLOGY

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EDITED BY

GEORGE H. F. NUTTALL, F.R.S.

QUICK PROFESSOR OF BIOLOGY IN THE UNIVERSITY OF CAMBRIDGE

ASSISTED BY

EDWARD HINDLE, PH.D.

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VOLUME X MAY, 1918 No. 4

COMBATING LOUSINESS AMONG SOLDIERS AND CIVILIANS.

BY GEORGE H. F. NUTTALL, M.D., PH.D., SC.D., F.R.S.

Quick Professor of Biology, Cambridge.

(*From the Quick Laboratory, University of Cambridge.*)

(With Plates X—XIII and 26 Text-figures.)

CONTENTS

INTRODUCTION.

> "Man, the chief lord of other animals, is, notwithstanding his power, the food and ordinary abode of this vermin, who riots in his blood, and sometimes colonizes his body with innumerable and detestable offspring. When such a mean, disgustful insect as this, can raise legions sufficient to render thee loathsome, and even to destroy thee, O man! where is thy boasted greatness?" BARBUT (1781, p. 328).

THE unprecedented scale of the present war, coupled with the conditions under which it is being fought, has led to a prevalence of lice among soldiers that has never been equalled in the world's history.

That lice are prone to infest soldiers has long been known. Moffett (ca. 1590, ed. 1658, p. 1190) wrote: "It is a beastly creature, and known better in Innes and Armies than it is welcome." At the time of Queen Anne (1702–1714) we find the *London Spy* describing the Foot Soldier of the period and saying: "Hunger and Lousiness are the two distempers that Afflict him; and Idleness and Scratching the two Medicines that Palliate his Miseries[1]." Old references to the prevalence of lice in troops could easily be multiplied. The trouble due to them is referred to in writings dealing with the Napoleonic, Crimean, and other wars.

When the present war broke out, there was much carelessness displayed in dealing with recruits, the lousy being intermingled with the clean in reckless fashion whereby the scourge of pediculosis descended as a veritable pandemic upon the soldier population. This recklessness was but partly due to the circumstance that recruits had to be rapidly assembled. However, much has been learnt since, and prophylactic measures conducted in an intelligent manner are being more generally employed.

The task of combating lousiness in armies at war offers innumerable difficulties because it is frequently impossible to carry out preventive measures adequately and half measures may be practically useless. As in the past, much depends upon the intelligence of combatant officers and their willingness to accept the advice tendered by their subordinate medical and sanitary officers. Although it has been amply proved that slovenly and makeshift methods are of little avail, there are many who from ignorance still persist in applying them. To deal with lousiness in the army, education is as much needed as among civilians. It is required both in the higher and lower grades, for in armies no measures possessing any value can be taken without the authority of higher combatant officers. The medical officer is there merely to advise.

In the following pages I have sought to bring together and classify

[1] Quoted in Ashton's *Social Life in the Reign of Queen Anne*, II. 200.

all the available information regarding the methods of combating lousiness among troops and civilians for, viewed epidemiologically, they must be regarded as forming one body. Much that serves to prevent lousiness will also check the all-too-prevalent scabies, both conditions being primarily due to neglect of the person, squalor, and filth. Frequent inspection, accurate diagnosis, frequent baths and adequate treatment cut at the root of both evils.

The general arrangement of the subject matter is sufficiently indicated in the table of contents. The scattered observations of different authors have been utilized as far as possible, due credit being given where it belongs. A number of unpublished observations of my own are incorporated throughout the text, these being duly indicated. A series of Reference Numbers accompanies the data bearing on experiments with insecticides, they run on into those relating to various remedies that have been recommended in practice; these numbers are merely intended to facilitate cross references.

To combat lousiness effectively it is essential to understand the biology of the parasites, a subject that has already received exhaustive treatment in my earlier papers in this volume of *Parasitology* (see Biology of *Pediculus humanus*, pp. 80–185, and that of *Phthirus pubis*, pp. 383–405; the relation of lice to disease is described on pp. 43–79, 375–382). The reader is referred to these publications.

I have to express my indebtedness to Sir Alfred Keogh, G.C.B., Director General, A.M.S. (now retired), for his help in kindly placing at my disposal the unpublished *MS. Reports to the War Office* by Mr A. Bacot, Entomologist to the Lister Institute; Captain C. J. D. Gair, R.A.M.C.; Captain J. T. Grant, R.A.M.C.; Lieutenant A. D. Peacock, R.A.M.C., and Colonel W. Hunter, A.M.S., of which a digest is incorporated in various parts of the text where indicated. I am furthermore under obligations to Colonel W. H. Horrocks, C.B., A.M.S., and Major W. C. Smales, R.A.M.C., War Office, for the help they have given me in various ways. Finally, I have to acknowledge the courtesy of several firms for placing at my disposal the blocks used for printing the illustrations of the different types of disinfectors which they have severally supplied to the armies in the field.

It is hoped that the mass of information here collected for the first time will be of benefit in guiding others to fresh discoveries whereby the scourge now afflicting our armies may be mitigated.

This publication deals with part of a general investigation undertaken in the Quick Laboratory before the war but left incomplete through

the departure of Messrs E. Hindle (Captain, R.E.) and L. Harrison (Lieutenant, R.A.M.C.) who were obliged to abandon their work which consequently devolved on me. The expenses of the investigation have been met, in part, by a grant from the Local Government Board.

I. PREVENTION.

GENERAL MEASURES FOR GUARDING AGAINST INFESTATION WITH LICE.

Education.

Many persons, especially belonging to the better classes, only know of lice by name, the name being virtually taboo in good society. Even a medical writer, and a German at that, wrote three years ago: "Welcher anständige deutsche Mann hat sich vor diesem Kriege um Läuse gekümmert" (Pinkus, II, 1915, p. 239), whilst a distinguished British entomologist refers briefly to them stating that they "are disgusting insects about which but little is known." When scientific men express such opinions it is easy to understand the prevailing ignorance regarding these ancient parasites of man. Now that it has been established that they are capable of communicating deadly diseases besides inflicting much misery on mankind we must hope that lice will receive the attention they deserve[1].

Among persons who suffer from lousiness[2] a certain knowledge may exist as to the mode of dealing with the pest, but often this knowledge must scarcely be greater than that possessed by apes and monkeys, otherwise it is difficult to explain the frequency with which the ignorant lower classes allow themselves to become heavily infested.

An individual who is liable to become infested should at least know enough of lice to recognize them, so that he may, if he wills, take prompt measures to rid himself of their presence. Therefore, in combating lousiness, it is essential in the first instance that steps be taken to educate the people as to their significance. Such educational efforts should commence in the schools.

Civilians. Sobel (1913, p. 663) has found in the schools of New York that the conditions there have improved in consequence of instruction and periodic inspection of children coupled with consultations with parents at school and in the homes; practical demonstrations at home; exclusion from school of children with lice upon them, aggravated

[1] See my paper in this vol. pp. 43–79 for a complete statement on this subject, except for the newly reported discoveries bearing on Trench Fever of which a preliminary report appeared in *Brit. Med. Journ.*, 23. III. 1917, p. 354.

[2] "In greke it is named Phthiriasis, In Englyshe it is named lousines." (Boorde, ca. 1547.)

cases and those refusing treatment; co-operation among teachers and pupils; mothers' meetings; distribution and explanation of circulars of information; instruction in personal home hygiene and cleanliness.

Soldiers. Instructional courses regarding lice have been recommended by various authors who have had experience in the present war. Thus Peacock (1916, p. 57) advises the distribution to soldiers of instructional leaflets stating how lousiness arises and how it can be mitigated. Unquestionably the intelligent soldier will be grateful for the opportunity of acquiring any knowledge that will lessen his discomforts and promote his efficiency.

Prejudice and superstition regarding lice still persist to a considerable extent and these cannot be dismissed by ridicule, they can only be combated adequately by persistent educational effort. They are a legacy handed down from olden times. Thus Paulus Aegineta and likewise Avicenna[1] (A.D. 980–1036) taught that lice are useful in removing "peccant humours" from man. In Linnaeus (1767, p. 1016) occurs the curious passage in relation to the head-louse: "Rodendo caput excitat Achores apud puerulos voraces incarceratos indeque strumosos, sicque praeservat a Coryza, Tussi, Caecitate, Epilepsia, etc., instante pluvia descendit ad latera capitis[2]." Knott (1905, pp. 188–195) refers to the belief still prevailing in Ireland that head-lice are beneficial and I am informed on good authority that a like belief holds in Scotland among the lower classes, a hardy louse population on the head being regarded as a sign of good health. Knott (*loc. cit.*) cites Poignet, the French dermatologist as stating that the ignorant in France hold a similar belief, lice being useful "pour suçer le mauvais sang" and they should therefore not be destroyed; even at the present day there are mothers who place lice upon their children's heads as a protective and curative measure. Shipley (1916, p. 16) quotes Dr R. J. Drummond as stating that there is a belief among the ignorant that lice are a sign of productivity.

[1] Cited by Knott (1905). This author, moreover (p. 194), records instances of lice being used formerly in therapeutics.

I find Moffett (ed. 1658, p. 1093) stating that 12 bruised lice in wine cure jaundice as "experience proves"; he regarded the appearance of lice on the heads of the sick as affording a good prognostic sign, i.e. the disease "flying forth from the centre to the circumference."

[2] I am indebted to my friend Mr V. S. Vernon-Jones, Lecturer in Classics, Magdalene College, for the following translation: "By biting into the head produces sores in greedy children when they are confined and consequently scrofulous, and so preserves them from catarrh, cough, blindness, epilepsy, etc. When rain threatens it descends to the sides of the head." [The last sentence possesses some biological interest, the lice no doubt dislike being wetted.]

"They transfer, by a process of sympathetic magic, the productivity of the lice to the lousy." Shipley adds that similar views prevail in parts of India and the East. My late friend Dr John Hewetson (1894, p. 19) records the case of an Austrian ex-soldier who was admitted as a patient to the Johns Hopkins Hospital, Baltimore, the man objected to the removal of the hair and *Phthirus pubis* from his body because he believed the latter brought "luck to the bearer and each [louse] sells for 5–10 kreuzers among the soldiers. They had been carefully carried by him for ten years."

It is clear from the foregoing that education is essential in the campaign against pediculosis.

Cleanliness and Measures which promote it.

"A louse is a worme wit*h* many fete, & it co*m*meth out of the filthi and onelene sky*n*ne....To withdryue them / The best is for to wasshe the ofte*n*times, and to chaunge oftentymes clene lynen." (Quoted by F. J. Furnivall in his edition of *The Book of Quinte Essence* (A.D. 1460–1470), London, 1866, p. 19, footnote.)

The statement that with the spread of Christianity "the louse commenced to enjoy most exceptional privileges" (Knott, 1905, p. 188) may be questioned by historians, but it is doubtless true. The cleanly habits of the Romans, to which history and still existing monuments bear convincing evidence, were succeeded in the dark ages by a return to unhygienic conditions which persisted through many centuries. The dark ages were likewise "the age of the louse." Certain saints that are reputed to have never washed, that let their unkempt beards attain legendary lengths, that practised self-denial by living in filth and squalor, and wearing a single garment of dirty rags, may have been good examples to their fellow men in moral matters; but they were not so in matters physical and we must suppose that close companionship with them had its drawbacks. A long time elapsed before it was taught that not filthiness but cleanliness is next to godliness. The epoch extending from the dark ages down to our time might well be termed the great dark age of filth by a Roman. The advice given to Michelangelo by his father, never to wash but to rub himself with a dry towel, is on a par with what we know of some historical personages almost down to the present day. A large proportion of our population has long been called "the great unwashed" because this is literally true.

Bathrooms in dwelling houses are but an innovation of recent decades, the vast majority of the population enjoy no bathing facilities whatever unless, at some personal inconvenience, they seek the public bathing establishments which some towns provide. Indeed, the first

public baths were only established in England in 1842–46 and there are still many towns unprovided therewith. In short, a great part of the population composing so-called civilized nations is living to-day in a state of filth that would offend many a savage.

Care of the Body.

A weekly *bath* and change of underclothing is a safeguard against infestation with lice under ordinary circumstances. Hot baths and Turkish or Russian baths are much to be preferred to cold baths. Where a person has been in contact with verminous persons or their effects a hot bath with a good soaping and rubbing down followed by a complete change of clothing is advisable.

Anointing the body with oil or fat will doubtless afford a measure of protection for the same reason that cosmetics applied to the head have been found useful. The objections to oiling the body otherwise than moderately are that it impedes evaporation from the skin and soils the clothing. Oils and ointments after the bath were already used by the ancient Hebrews, and the Romans anointed their bodies with oils and pomades (smegmata) at the conclusion of the bath following upon the *use of the strigillus* and *rubbing*—both of these processes would remove ectoparasites.

Care of the Head.

The lack of care of the head among the lower classes of the civilian population is directly responsible for the great prevalence of head-lice among them. As lice *chiefly infest persons with long hair*, i.e. women and young children (see p. 84), these may be considered first.

In the upper classes head-lice may occasionally be picked up, but infestation is on the whole a rare occurrence owing to the care that is devoted to the hair by *daily combing, brushing and periodic washing.* When lice appear, they are promptly dealt with by the well-to-do because their heads undergo what practically amounts to *frequent inspection* during the toilet. Where infestation occurs in such cases, it is usually in girls of school age who come in contact with unclean persons or pick up stray lice in the manner already described (see pp. 94 et seq.). In girls of this class, infestation will usually be prevented by *braiding the hair* at school and unbraiding it at home.

In *schools* resorted to by children of different classes of society, mothers may well be advised to keep the *girls' hair cut short* until they leave school (Raven, 1907, p. 64), especially if reinfestation occurs at intervals in spite of ordinary care and cleanliness applied to the head.

Girls should have lockers or bags for their effects and should not hang their *hats* on pegs in schools (see p. 98 and Sobel, 1913, p. 656) because clean hats may become infested through contact with those that are verminous. Harding (1898, p. 95), who found lice in school-girls' hats in the course of inspections, states that he has always ordered the hats to be sponged with 10 per cent. carbolic acid solution if any were found verminous.

That cutting the hair short affords a great measure of protection against head-lice is proved by statistics (see p. 84), but it may not be sufficient to afford immunity if opportunities for infestation are frequent and the head is neglected, i.e. not sufficiently combed, brushed and washed. Under such circumstances *the shorter the hair is cut the better*, and because of this it is not uncommon, especially on the continent, to see children's and men's heads clipped so short that they almost appear to have been shaved. This constitutes *a preventive measure long recognized in Continental Armies* (Russia, Germany, France).

In the case of school-boys the dissemination of lice through the contact of *headgear* on pegs should be prevented by the boys being made to put their caps in their desks or pockets.

The *shaving of the head* together with the use of wigs in former times must be regarded as having constituted an effort to do away in the upper classes with the all-prevalent head-lice of the general population. The custom of shaving the head wholly or partially among many peoples both ancient and modern[1] and among the priesthood, dating from the time of the Egyptians and beyond, doubtless arose in a similar manner.

Among the simple preventive measures involving no medication may be reckoned *the use of hair oil and pomade* to which the immunity of certain classes has been attributed (see p. 85). The drawback to the use of greasy hair cosmetics is that they soil hats and pillows, but the frequent disuse of headgear now-a-days partly removes this objection.

Care of Clothing.

Outer garments with a rough texture are more liable to pick up stray lice than are smooth surfaced clothes, therefore the latter are to be preferred where choice is possible and liability to infestation exists. Relatively

[1] As examples which need not be multiplied, I may mention that Mr Claude Fuller informs me (1917) that the negroes of Natal shave their heads against lice, whilst Mr W. Mansfield Aders, writing (1918) from Zanzibar, states "As far as my experience goes lice are not common on African negroes in Zanzibar, chiefly owing to their cleanly habits and that they shave their pate, arm-pits and pubic region. On the other hand Indians who are very dirty and allow their hair to grow long are often swarming with lice."

speaking, outer garments harbour fewer lice than do the underclothes of infested persons. According to circumstances the more or less frequent inspection, brushing and beating of the external clothing will afford a measure of protection by dislodging casually intruding lice.

The headgear as a means of disseminating lice among school children has already been referred to (vide supra).

Underclothing. The better educated classes who wear a full suit of underwear usually change the suit once a week, a proceeding which practically assures them against becoming louse infested. Many relatively well-to-do men in this country have the filthy habit of not wearing drawers, such people are naturally more prone to harbour lice. *Smooth and seamless clothing is the best.* Where there are seams, the overlapping should be as slight as possible so as to afford little or no retreat for lice. Folds and puckers should therefore be avoided in underclothes. Woollen underclothes are unfortunately prone to harbour vermin as old experience has taught:

"Some kind of cloath likewise is apt to ingender lice, and especially those which are made of wooll that sheeps bare which were worried of wolves." Philemon Holland[1].

Bedding. As a matter of routine, experienced travellers, especially in some countries, always inspect the bedding with which they are supplied to see that there are no vermin present, it being a common trick of unscrupulous hotel and boarding house keepers in some places to palm off smoothed but soiled bed linen on innocent guests. If the previous occupant of the bed was verminous the traveller may readily acquire the parasites unless he takes precautions. The prevalence of lice in common lodging houses in London has already been noted (see p. 87). *Blankets,* from the nature of their texture and the fact that they are infrequently cleansed, are liable to harbour lice; they should not be laid down in places occupied or that have been occupied by verminous persons or their effects since lice readily cling to them.

Protective Clothing.

The use of smooth surfaced outer clothing to which lice cannot cling has been advocated by a number of recent writers[2] and the employment of such protective clothing is obviously indicated in the case of physicians,

[1] Cited by Knott (1895, p. 189). Moffett (ed. 1634, p. 262) makes the statement: "Lana ovis à lupo ceeissae pedieulos gignit, si vestis ex ea sudore madeat: quod sane Aristotelis Pliniique eommentum sit;...."

[2] Flügge, Neufeld, Gärtner, Kraus, Letulle, Letulle and Bordas, Mendes, von Wasielewski, Galewsky, Adler-Herzmark. Flügge makes the unpraetieal suggestion that the coat

nurses and others, espeeially when in attendanee on typhus and relapsing fever eases. Sueh elothing should also be used by persons who have to handle verminous individuals and their effeets. The reader is referred in this conneetion to the seetion dealing with the modes of infestation and dissemination of liee (pp. 94–95). The ordinary outer elothing of medieal attendants should also be as smooth as possible. *Rubber or oiled silk* are best for proteetive purposes, since they possess the smoothest surfaees. The eoat should be long, extending well below the knee and buttoning down the back; the *sleeves should be narrow to the wrists* and rubber gloves should be drawn up so as to overlap the edges of the sleeves; the eollar should button elose around the neck, the head being eovered by a hood; rubber or smooth leather top boots may be worn. Failing rubber, a suit of smooth fabric opening at the neek like a bathing suit with buttons at the shoulders may be substituted, it should be all in one, with the trousers elosed at the ends like large stoekings, sandals being worn over them on the feet[1].

Referenee has already been made to the use of *silk underwear* (p. 95) as a protection against liee and its ineffieieney pointed out. It has been recommended as a sure preventive by Kisskalt (1915, p. 154), as really useful by Meltzer (1915, p. 532) and Heymann (1915, pp. 254, 320). Kisskalt and Friedmann (1915, p. 398), on the other hand, state that experienees with silk are eontradictory, whilst Marschalko (1915, p. 316) eondemns silk underwear as unpraetieal, eostly and ineffective, Gleber having informed him that many offieers beeame heavily infested in Galieia although they wore silk underwear. From my experiments I would eonclude that silk tricot is useless whilst *smooth* silk may well afford a measure of protection.

Avoiding Contamination.

The modes of infestation and dissemination of liee have already been eonsidered fully (see pp. 94 et seq.) and all that need be said here is to lay stress upon the neeessity of avoiding as much as possible eontaet with verminous persons and their effects. The overcrowding of men, one or more of whom may be infested, is the most common eause of the spread of liee.

should be sealed about the neek and sleeves with adhesive plaster; Gärtner advises smearing "a repellant" upon the over-alls, whieh seems superfluous; a better suggestion is that of Letulle and Bordas (1915, p. 245) to wrap eotton wool around the wrists and neek, the liee beeoming entangled therein.

[1] This form of over-all suit was adopted by the staff in Serbia after various trials aeeording to Maitland (1915, p. 283).

Free Ventilation as a help.

It has long been held that fresh air is of benefit in checking the spread of typhus fever, good results having followed the free ventilation of wards by opening the doors and windows or by placing the patients in the open in a lean-to or tent. Thus Cheyne (1818, *Dublin Hosp. Rep.* II, 53)[1] recorded very few cases of typhus extending in houses in which "proper attention was paid to cleanliness and ventilation" and subsequent authors have made similar observations. Jacquot (1858, *Le typhus de l'Armée d'Orient*, p. 64)[1] wrote of the Crimean war: "Pas de typhus l'été alors que le soldat vit en pleine air et laisse ouvertes les barraques ou les tentes." Recent experience has been similar, thus Hartmann (1915, p. 861) cites Curschmann as having laid stress on the open air treatment of typhus owing to the excellent results obtained in the epidemic of 1879 at Moabit Hospital, Berlin.

Since all the evidence hitherto collected points to lice as the sole means whereby typhus is transmitted from man to man, it follows that free ventilation during the cool weather in which epidemics mostly occur must impede the conveyance of lice from man to man. The beneficial effect of fresh air is doubtless attributable to the cold checking the wandering of lice, the insects remaining near the warm bodies of the sick and becoming torpid when they become cooled. This view was also expressed in 1915 by Boral (p. 641), Frisch (p. 367) and von Wasielewski (p. 627).

Frequent Inspection essential.

Experience in the Army has convinced competent observers that frequent inspection of men and their clothes is necessary to diminish the prevalence of lice and to keep the men clean. Inspection is needed because men may be careless or desirous of concealing their condition from fear of being considered unclean, or the men may be infested without knowing it. A case in point is recorded by Busson (1915, p. 674) wherein a faithful hospital attendant, when inspected, to his own great astonishment was found to be a "Massenträger" (a heavily infested carrier).

Inspection should be carried out *once a week* (Heymann, 1915, p. 320; Peacock, 1916, p. 59), and should include the men's bodies and their clothing. The inspection should be carried out by a quick intelligent person; special attention should be paid to men who are prone to be habitually dirty, these being frequently a main source of lice in a group

[1] Quoted by Hirsch, 1881, pp. 413, 414.

of men; such individuals quickly reinfest their cleaned fellows and often lead to billets and dug-outs being wrongly blamed as sources of infestation. The men should be stripped for inspection, their clothing being rapidly removed immediately before and turned inside out. The underclothes and outer garments should be examined, special attention being given to the shirt, the seams in the clothing and the fork of the trousers as being the most likely places to harbour lice and nits (see pp. 91–93). Several observers draw particular attention to the large number of nits that may be present beneath the small piece of linen covering the rough seams at the fork. The Scotch kilt with its many deep folds is a notorious abode for lice.

Head-lice whether on soldiers or civilians and children should be looked for at the occiput and sides of the head, above and behind the ears. In cases of slight infestation the nits are more readily detected than the active stages and they are best seen on dark hair; recently laid nits will be found at the hair bases.

Phthirus will naturally be looked for most frequently in the pubic region, next in the axillae and lastly about the eyelashes where it but rarely occurs (see this vol. p. 385).

II. LOUSING BY MECHANICAL MEANS.

1. *When the head is infested.*

(*a*) *Pediculus.*

In mild cases of pediculosis the lice and their nits may be removed by *hand-picking* and *combing* with a fine comb. It is a process that has been employed from time immemorial and is commonly used among primitive peoples. Murillo, Teniers and other artists did not think it beneath their dignity to illustrate the process of lousing[1]. As usually employed, the

[1] The word *lousing* has become rare owing no doubt to the decreasing lousiness of the population. It can no longer be said of head-lice: "the heads of young children that are almost allways full of them" (Moffett, ed. 1658, p. 1091). *To louse* signifies "to clear of lice, remove lice from (a person, oneself, a garment)" according to *Murray's Dictionary*, therefore *de-lousing*, as frequently used to-day, is unjustified (we would not ask a person to de-weed a garden!). Lousing (*lowsyn*) was used in 1440 (Murray); "Efte was she busy *lowsynge* and kemynge" (1514, Barelay, A., *The Cytezen and Uplondysman: an eclogue*. Printed from the orig. ed. by Wynkyn de Worde. Ed. by F. W. Fairholt, London, 1847). "Howe handsome [convenient] it is to lye and sleepe, or to *lowze* themselves in the sunshine" (Edmund Spenser (1590–1600). *View of the Present State of Ireland*, published 1633). "To York House, where the Russia Embassador do lie; and there I saw his people go up and down *louseing* themselves" (Lord Braybrooke's ed. *Pepys' Diary*, vide 6 June, 1663); I find that the word louseing is not in shorthand in the original MS. at Magdalene College, Cambridge. See also Stevens' translation of Quevedo (1707) and Hearne (1795), of which

method serves mercly to keep down the louse population within reasonable bounds; to be effective, however, it must be frequently repeated and this takes much time. Hand-picking and combing are best supplemented by head washing with soap and water, decoction of Peruvian bark or some other hairwash. Advantage should be taken of Howlett's discovery (1917, p. 188) previously cited (p. 179), that if a *comb warmed* enough to be pleasantly hot to the hand be used, the lice abandon their "dugouts among the bases of the hairs" and "are removed with a very marked economy of time and labour," the insects being repelled by the heat emanating from the comb. The nits and lice are usually crushed between the fingers by habitués but their consignment to the fire is preferred by others. In more heavily infested heads it is practically impossible to remove the parasites by this method.

Cutting and shaving the hair, already mentioned as a preventive (see p. 419), are efficacious methods of removing lice mechanically and constitute an ancient remedy. Shaving is very generally recommended in cases of severe infestation. It is a radical measure, for in the absence of hair upon which to lay their eggs, head-lice cannot persist on an individual unless perchance they acquire the habits of body-lice and learn to oviposit on clothing or spread to other hairy parts of the body (see p. 94). The shaving is greatly facilitated by previously clipping the hair as short as possible. The clipped and shorn hair should be collected on a large sheet of paper in which it can be rolled up and burnt. It may be necessary to leave areas of clipped hair in places that show scratches and scabs; such hairs should be cut down to near the base with a fine scissors. The shaving may be carried out either in a chair, when the person is lying down, or in a bath; for a bath and general soaping down and scrubbing should follow whenever possible, and be succeeded by a complete change of clothing. This should certainly be a routine practice in hospitals, prior to the admission of verminous patients to the wards.

Merely cutting the hair short is insufficient for the mechanical removal of lice, because some of them cling closely to the skin and their eggs are laid very near to the roots of the hairs. The freshly laid unhatched eggs are almost invariably found close to the hair root, at a distance of about 1 mm. from the skin, whilst the empty or shrivelled egg-shells occur further along the hair and their removal in numbers may convey the false impression that clipping the hair short is sufficient.

citations occur in the Supplementary Notes at the end of this publication. My friend Dr A. E. Shipley writes: "I can, if you like, send you a score of examples of *Lousing* being used by the best classical English writers."

A close examination of the scalp about the ears and nape of the neck will, however, reveal the parasites, these regions being well-known sites of predilection for *capitis*, a matter that should be remembered in connection with any form of head-treatment for pediculosis. Where shaving cannot be practised, the cutting of the hair short is the next best procedure because it facilitates inspection and the application of insecticides. There is usually no difficulty about cutting the hair short in boys and men but obvious objections are encountered in the case of women and young children in whom the possession of long hair is a source of pride.

In severely infested heads showing lesions due to scratching, etc., shaving and washing may not suffice because lice may be harboured beneath crusts and scabs. In such cases insecticides will have to be used in addition.

The application of insecticides may follow or accompany the mechanical removal of lice as above described, or insecticides alone may have to be relied upon in dealing with hair that cannot be cut. The methods of applying insecticides to the head are described on pp. 520 et seq.

(*b*) *Phthirus.*

Crab-lice occur very rarely on the scalp-hair and beard; when present in these situations or upon the eyebrows they can be dealt with by the same methods that apply to *capitis*. When crab-lice occur on the eyelashes, as is more frequently the case, the insects and their nits may be picked off one by one with a fine forceps. The procedure requires patience. Bleicher (1882, p. 976) recommends the application of balsam of Peru about the eyelashes before proceeding to pick off the lice and nits, all the parasites being removed at one sitting. Jullien (cited by Dubreuilh and Beille, 1895, p. 139) removed 100 crab-lice in this way from the eyelashes of a patient. Brault (1906, p. 70) describes two cases in young men from whose eyelashes he picked off lice; in one case he applied yellow oxide of mercury ointment afterwards and effected a rapid cure. It is worth repeating that numerous nits on the lashes may give them a dusty appearance and that the lice at the lash bases may escape notice unless looked for closely.

2. *When the body is infested.*

Shaving the infested part or the whole body if need-be is the usual mechanical method used for the removal of *Phthirus* or *Pediculus* from the

body[1]. There are objections to shaving the pubis and especially the axillae, particularly in soldiers on the march, because of the tickling and irritation produced by the growing hair, moreover, in some circumstances, the use of insecticides is preferable, especially in the case of wounded men. The hair removed by shaving should be carefully collected on paper and burnt.

Failing the foregoing means of disposing of the parasites, the suggestion contained in the references made elsewhere to Michelangelo (p. 417) and to Leeuwenhoek (p. 105) indicates that *hard rubbing* of the skin either with a rough towel or with the hand must necessarily serve to displace many of the parasites, and the procedure would certainly mitigate the evil in cases of generalized infestation with either species of louse.

3. *When the clothing is infested.*

Brushing, beating and hand-picking of infested garments, when well carried out, greatly reduces lousiness, and if done thoroughly, say once a week, it would perhaps be sufficiently effective to render more elaborate measures unnecessary for soldiers in the field. The parts of the clothing to be examined have already been referred to (see p. 423). Teske (1915, p. 346) reports that good results have often followed the simple beating of clothes in the German army, whilst Legendre (1915, p. 83) states from his experience with French troops that periodic brushing for 15 minutes, using a hard brush, has given satisfaction. Trappe (1915, p. 1266) relates that he cleansed his battalion in a few days by the process of hand-picking; he prefers it to the use of steam or chemicals which he regards as mere palliatives; his men examined their own clothing, scraping off the nits with the finger nail or knife. The men in the trenches spent about half an hour a day in inspecting their clothes under supervision, those having good eyes helping others that had not. The method is naturally difficult to apply in winter.

It is impossible to deal efficiently with cardigans and some forms of underclothing by the foregoing method. In such cases the articles will have to be treated by heat or chemical agents.

[1] I have stated elsewhere (p. 92) that *corporis*, contrary to accepted opinion, does lay nits on man's body hair. This statement has received further confirmation, for Darier (II. 1918, p. 223) cites Bulliard (*Ann. de Dermatol.* VII. 1917) and Lemon and Barber, as recording the frequent occurrence of *corporis* nits on the pubic and axillary hair, where, as I have also shown, *capitis* may likewise be present.

Drying and Storage of Clothing and Effects as a Means of Louse Disposal.

In the section on Biology of *Pediculus* full details are given regarding (1) the longevity of the active stages when starved (pp. 164–169) and (2) the hatching of nits under different conditions of temperature (pp. 143–147). The information quoted shows that the active stages live 10 days, at longest, when unfed, and that hatching does not occur at a temperature of 22° C. or below. The longest hatching periods recorded are 16 days at 25° C. in a dry atmosphere, and 23 days in a damp atmosphere at 24·5° C. In a dry atmosphere, the temperature being constant, the longest hatching periods observed were 14 days at 30° C., 7–8 days at 32–35° C. and 7 days at 37° C. When nits were exposed alternately for periods of 12–24 hrs. to cold and warmth, hatching could be delayed, in extreme cases, for 35 days, but such alternating conditions need not concern us in relation to the storage of verminous effects where a more uniform temperature will be maintained, usually below that (22° C.) which permits of the development and hatching of the egg. Under ordinary conditions, at a temperature of 12–20° C., *dry storage for 2–3 weeks should suffice in practice* to dispose of the nits which are considerably more resistant than the active stages. The nits usually commence to shrivel up in a few days when kept dry but it is best in practice to prolong the storage period.

This conclusion regarding the requisite storage period is in agreement with that arrived at by other observers. Stevenson (1905) in the case of the hog-louse recommends that infested pens should be left vacant for 2 weeks so that the therein contained lice may die. This recommendation is evidently based on actual experience, and it accords closely with what appears to have been observed in practice with the human body-louse. Thus Busson (1915, p. 674) recommends that "infested quarters" shall be disused for 2 weeks, Ragg (1915, p. 172) that clothing be stored 2 weeks, but neither author mentions at what temperature. Heymann (III. 1915, p. 254) in one paper recommends the storage of clothes for 2 weeks "in tightly closing boxes" (no reason given), whilst in another paper (VIII. 1915, p. 318) he advises 3 weeks' storage, at room-temperature.

The drier the atmosphere the shorter will be the period of storage required. A storage room heated by a stove or radiators, during the winter months especially, and provided with adequate ventilation would doubtless destroy nits and lice within a week. To ensure rapid desiccation the clothing, blankets, etc., should not be stacked in bundles, but

should be suspended on hooks or wires so that they are freely exposed to the dry circulating air.

III. DESTRUCTION OF LICE.

GENERAL CONSIDERATIONS.

Sham Death of Lice.

A Source of fallacious Conclusions regarding the Effects of Insecticides and Heat.

The reports of various authors upon the effects of insecticides on lice have convinced me that many have been led into error through the occurrence of sham death in the insects under experiment. I have already referred to the subject and stated what constitute the unequivocal signs of death that should be accepted in practice (see pp. 183–4), and would add here merely that the phenomenon of "turning red" is observable in lice killed by exposure to moderate dry heat (70° C.); dry heat, therefore, may be added to the list of causes of this condition.

The authors who exclude sham death as a source of error from their experiments are Pregl, Felix, Knafft-Lenz, and Heymann in 1915, and Seitz, Swellengrebel, and Peacock in 1916.

Some of the results recorded by the following authors are fallacious because they obviously assumed that merely immobilized lice were dead: Jeanneret-Minkine, Legendre, Prowazek, Galewsky, Zupnik, Kulka, Busson, Sergent and Foley, Widmann, Castellani and Jackson, Musselius, Vishnjakov in 1915, and Kinloch in 1916. These authors, as a rule, state that various remedies kill lice in an impossibly short time, other more carefully conducted experiments proving the contrary. For example Prowazek states that ether kills *Ph. pubis* "instantly"; Sergent and Foley state that oil of eucalyptus dropped on verminous cloth kills clothes-lice "in a few moments"; Castellani and Jackson assert that petroleum (kerosene) kills lice "almost instantaneously" and that vaseline kills them "instantaneously," etc., etc. Busson mentions that sham death occurs, but his experimental results prove that he did not apply his knowledge in practice, and the like holds for Galewsky (III. and V. 1915). Widmann placed reliance upon the totally inadequate evidence of the cessation of intestinal peristalsis in lice as a sign of death, whilst he experimented with so few nits that the chance of some being sterile was not excluded at the start. The positive results given by the foregoing authors are therefore largely excluded from my tables, because they are clearly fallacious. On the other hand I record their negative

results, i.e. those in which they found that lice or nits survived exposure to certain insecticides.

The relative resistance of the various stages of Pediculus humanus.

Most authors have failed to note any difference in the resisting power of lice at various active stages of their development. Prowazek (I. 1915, pp. 67–68) asserts that adults are more readily killed than larvae, whilst Legroux (VIII. 1915, p. 470) states that old females and young lice are the most susceptible; these statements are contradictory. According to Busson (1915, p. 674) freshly gorged lice are more susceptible than others to the effects of insecticides. In any case, such differences are not of importance; in practice the *nits* have to be destroyed and any method that falls short of killing them is bound to be ineffective.

The experimental evidence points to nits and active stages being about equally susceptible to the effects of *heat* whereas, as might be foreseen, nits are the more resistant to the influence of *insecticides*. This is rendered most evident by the experiments with vapours. It follows that the value of insecticides should be determined on nits and not on the active stages unless merely temporary results are to be obtained, treatment being repeated periodically.

I. DESTRUCTION OF LICE BY HEAT.

Experimental Section.

Regarding the temperature that is required to kill *corporis*.

1. *Dry Heat.*

(*a*) Experiments with Nits.

Temperature °C. (dry heat)	Length of exposure in minutes	Result +=killed o=survived	Authority (reference see p. 435)
72°	½′	+ 52 nits 4 days old at 30° C. tested. All slightly clouded, many shrunk. *All killed*, 14/16 of controls hatched	Nuttall
70°	1′	+ and shrivelled	,,
70°	5′	+	Friedmann
65°	1′	+ mostly shrivelled	Nuttall
62°	5′	+ shrivelled	,,
61°	10′	+ ,, ...	,,
60°	5′	+ and dried at once (3 nits)	Widmann
60°	20′	+	Lelean
55°	10′	+ and shrivelled (3 nits)	Widmann
54°	35′	+	Bacot
52°	30′	+ and 50 % shrivelled	Nuttall
50°	15′	+ and shrivelled	Widmann
49°	25′	+ but not shrivelled	Nuttall
45°	15′	o 2 nits survived exposure	Widmann

I omit from the foregoing table the records of the experiments by Kisskalt and Friedmann (1915, p. 397), Fränkel (VI. 1915, p. 301), Heymann (III. 1915, p. 253) and Zucker (1915, p. 294) who obviously exposed the insects to a high temperature for unnecessarily long periods. Kisskalt (II. 1915, p. 154) states that 70° C. kills nits but does not give the time of exposure. Wulker merely states that nits are "quickly" killed at 60° C. and that they appear to coagulate. None of the authors cited here and in the table record how they tested the thermal death-point of nits.

My tests were carried out as follows: 50 fertile *corporis* eggs, laid on hair 24–48 hrs. before, were tied in bunches of 5 with silk thread. One end of the thread was weighted with a piece of wire whereby it was lowered vertically into a Nuttall microscope-thermostat through the centre of a glass tube attached by rubber bands to a thermometer. The nits were lowered to the level of the thermometer bulb which extended slightly below the bottom of the tube into the heated chamber. The eggs were examined microscopically after exposure and subsequently incubated at 30° C. with controls to see if they hatched.

The foregoing records demonstrate that *corporis* nits are killed by dry heat at 65–70° C. in 1 minute, and at 55–61° C. in 10 minutes.

(*b*) Experiments with the active stages.

Temperature °C. (dry heat)	Length of exposure in minutes (′) & seconds (″)	Result +=killed ±=some killed o=survived	Authority (reference see p. 435)
72°	½′	+ 2 ♂ 1 ♀ killed (Turned red in 1 hr at 30° C. Young adults fed ca. ½ hr before heating)...	Nuttall
71°	1′	2 ♂ 1 ♀ ditto	„
65°	"promptly"	+ adults	Widmann
65°	"at once"	+ unfed lice	Zucker
65°	15′	+ gorged lice	„
65°	30′	+ no particulars	Kinloch
59°	25″	± 2 ♀ fed, one killed, one recovered and lively after 24 hrs	Nuttall
57°	45″	+ 2 ♀ fed	„
55°	1–2′	+ no particulars	Wulker
55–56°	5′	+ „ „	Galli-Valerio
50–56°	15–20′	+ „ „	Heymann
52°	2′ 30″	o 2 ♀ gorged, fell over as if dead in 2′ 10″ but lively after 24 hrs	Nuttall
50–52°	5–15′	+ no particulars	Galli-Valerio
50°	10′	+ „ „	Wulker
50°	30′	± ⅘ second stage larvae survived	Bacot
50°	30–45′	+ no particulars	Noeller
49°	2′	+ 2 ♀ unfed, one killed, one immobilized 24 hrs and died	Nuttall
48°	4′	+ 2 ♀ unfed	„

The authors quoted do not state how they conducted their experiments or whether lice exposed for shorter periods survived. Some observations by Heymann and Zucker are omitted from the table because they relate to needlessly long exposures. Prowazek (1915, p. 67) makes the absurd statement that lice die at 35° C. Bacot and Widmann are the only authors who mention the stages with which they experimented.

Except in one case my experiments were carried out with adults aged 5 weeks that had gorged 15–20 minutes prior to the test. The lice were dropped into small glass dishes resting on a cardboard box in a microscope-thermostat. A thermometer bulb rested on the floor of one of the dishes. The behaviour of the lice could be watched through the thermostat window, and the dishes, when exposure time was up, were quickly removed by forceps through the small hand-hole at the side without affecting the temperature inside. Exposed to heat, the lice at once became greatly agitated, in most cases voided excreta after a few seconds, and soon rolled over on their backs, their movements gradually subsiding. Some survived in an almost immobilized condition, others recovered completely and were as lively as ever after 24 hours (at 30° C.) provided they had not been exposed too long to the heat (vide table).

We may therefore conclude that adult lice are killed by dry heat at 65–70° C. in 1 minute, and at 55° C. in 5 minutes.

(*c*) Degree of Heat recommended in practice. Killing of nits and active stages on clothes.

In the following table I have summarized the statements found in the literature:

Temperature °C. (dry heat)	Time of exposure in minutes	Result +=killed	Authority (reference see p. 435)
120–130°	20′	+ lice roasted, nits crisp and crackly	Seligmann and Sokolowsky (apparatus, see p. 439)
100–110°	30′	+ ditto	„
60°	60′	+	Heymann
60°	60′	+ (on furs and leather)	Uhlenhuth
50–58°	15–25′	+	Engelhardt

It is evident that the foregoing authors, Engelhardt excepted, employed needlessly high temperature or unnecessarily long exposures for the purpose of killing lice; the experiments previously cited prove this conclusively. It seems absurd to waste fuel and time when the same

result can be obtained by more moderate means. In accordance with my experimental results I have long urged on those who had to do with practical disinfestation to employ lower temperatures (55–70° C.) for killing lice. This was urged not only in the interests of economy in fuel and time but also to save clothing from the deleterious effects of needless superheating. Experiments under practical conditions were carried out at my suggestion by Captain Harold Orr, Canadian A.M.C., and later continued by Captain J. T. Grant, R.A.M.C., and Lieut. A. D. Peacock, R.A.M.C., and these amply confirm my experimental results which were communicated to Captain Orr three years ago.

Grant and Peacock's experiments (*MS. Report*, W.O. I. 1918) were carried out in hot-air disinfestation huts (see p. 441) containing blankets or clothing together with living test-lice and nits supplied by Mr A. Bacot, Entomologist to the War Office. Active lice to the number of 15–20, and 50–100 nits, were used for each test, the insects being contained in gauze-covered pill boxes or attached to cloth. Maximum thermometers were used for recording the temperature, and the exposure time was reckoned from the moment that the desired maximum temperature was attained in the hut. The test-insects were distributed in various parts of the hut in the pockets of clothing, etc. After the lice had been exposed, they were kept under observation by Bacot to determine if any had survived. I extract the following essential data from the lengthy experimental protocols.

Orr's preliminary tests, made with lice and nits placed with clothing in various parts of the hut, had proved that exposure at 54° C. or at 60° C. for 15′ was lethal.

Maxim. temperature to which lice and nits were exposed °C.	Duration of exposure in minutes	Result (+=killed, or o=not killed)		Remarks
		Active stages	Nits	
48°	60′	o	o	
51·5°	15′	+	o	
53°	15′	+	o	lice soft
55°	30′	+	+	3 tests, lice soft
56°	20′	—	+	
57°	30′	+	+	
67°	15′	+	+	lice soft, nits shrivelled

These results do not give the minimum time required to kill nits and lice like those I have tabulated on pp. 429, 430, but they show what can be done under practical working conditions. Lice exposed to 48° C. and below survived; all lice and nits exposed to 55° C. or over were killed; 51–53° C. killed the active stages but not the nits. Therefore to allow a

good margin of safety *under working conditions* Captain Orr adopted an exposure at 60–65° C. for 15 minutes as adequate. Grant and Peacock recommend an exposure at 65° C. for 30 minutes.

2. *Moist Heat.*

(*a*) Immersion in hot water.

The following table summarizes the results of experiments conducted by various authors and myself:

(*a*) *Experiments with Nits.*

Temperature °C. immersed in water	Time of exposure in minutes and seconds	Result +=killed ○=survived	Authority (reference see p. 435)
100°	5″	+	Kinloch
98·4°	30″ and 60″	+	Bacot
88°	15″	+ 8 nits, collapsed after 20′	Nuttall
76°	30″	+ 4 nits, collapsed and opaque	,,
70°	10″	+ 21 nits, clouded, many shrunken, all collapsed in 24 hours ($\frac{14}{16}$ controls hatched)	,,
67°	1′	+ 4 nits, slightly opaque	,,
60°	5′	+ 4 nits, ,, ,, ...	,,
60°	5′	+ 4 nits, opaque, soon dried up	Widmann
55°	10′	+ 3 nits	,,
55°	30′	+	Bacot
54°	10′	+ 4 nits, appeared unaltered	Nuttall
50°	15′	+ 3 nits	Widmann
45°	15′	○ 3 survived and hatched in $7\frac{1}{2}$ days ...	,,
40°	1 day	○ 2 survived and hatched in 7 days ...	,,

(*b*) *Experiments with Active Stages.*

100°	1′	+ stage or number not stated	Galli-Valerio
70°	10″	+ 1 ♂ 2 ♀ turned red in 1 hr, dried up in 24 hrs	Nuttall
50°	30′	+ second stage larvae	Bacot

(*c*) *Exposure recommended by authors in practice.*

		Purpose	
Water + 10 % soda, boiling	2 hrs	for underclothes [heroic and no mistake] ...	Izar
Water + soda, boiling	15′	for underclothes	Heymann
Water at 100°	15′	,, ,, ...	,,
Water at 100°	5′	kills nits and lice [certainly sufficient] ...	Peacock
Water at 100°	a few′	for brushes and combs harbouring *capitis* [will scarcely improve brushes]	Greene
Water at 35°	—	for bath water, supposed to kill lice [nonsense]	Klemperer and Zinn

The foregoing results, coupled with other experiments of my own which were not protocolled, indicate that active stages and nits are killed

instantaneously by immersion in water at 90–100° C. and that even an exposure of 5 seconds at 70° C. is likewise fatal. Therefore, allowing a margin of safety under practical conditions, a thorough scalding of verminous effects or their immersion in hot water at about 70° C. for a minute or two will amply suffice to destroy lice. Since, however, nits and lice are killed at 55° C. in 10 minutes and this degree of heat perhaps causes less shrinkage in flannels, the exposure at the lower temperature might be practised with advantage under adequate control.

(*b*) Exposure to steam.

Steam Jet.

Nits, 24 hours old, were exposed for 1 minute in a steam jet at 90° C. They all became coagulated (whitened) and promptly collapsed (Nuttall).

Heymann (8. III. 1915, p. 53) states that a steam jet, as obtained from a railway train, will kill nits and lice promptly if applied once or twice to clothing. There is no doubt but that Heymann is correct in his statement.

Steam Sterilizer.

Although it is evident that *steam at* 100° *C. will kill lice and nits instantly*, both Kisskalt and Friedmann state that a 5 minutes' exposure is necessary, and Galli-Valerio gives the period as 2–5 minutes. When steam sterilization is *applied to clothing* in practice the exposure must necessarily be lengthened to insure the penetration of the steam into the clothes and their folds, seams, pockets, etc. The following table summarizes the practical observations of various authors as to the time required to kill lice and their nits.

Temperature 0° C. steam sterilizer	Length of exposure in minutes	Load	Kind of sterilizer, etc.	Authority (reference see p. 435)
115°	25′	"Clothes" ...	Adapted from brewery boilers in Flanders. After steaming, shake clothes which are warm and dry and ready to put on at once	Hönck
101·6°	45′	100 garments ...	Thresh disinfector	Peacock
101·6°	30′	60 blankets or equivalent	,, ,, ...	Lelean
90–100°	45′	"Clothes" ...	Not stated	Giese
100°	30′	,, ...	,, ...	Uhlenhuth
100°	30′	"Clothes, blankets and linen" ...	Serbian experience, barrels ...	Slammers
100°	20′	"Clothes" ...	Not stated	Legendre
100°	10′	,, ...	,, ...	Jeanneret-Minkine

It is a common experience to see lice survive when insufficient time has been allowed for the steam to penetrate clothing. I know of

two instances where large thoroughly efficient steam disinfectors were blamed as ineffective merely because they were *overloaded* and the time of exposure was too short. The greater the load the longer the exposure required. The ignorance of this rudimentary matter amongst persons responsible in an official capacity is very regrettable because so general. The length of exposure required cannot be determined off-hand; it must be established by practical experience with standard loads as it varies according to the type of disinfector employed. From practical considerations a period of 15 minutes should be allowed to elapse after the thermometer has reached 100° C. in the least accessible parts of the articles exposed to the steam.

References to authors cited in the foregoing section:

Baeot, I. 1916, p. 167—Castellani and Jaekson, 1915, p. 255—Engelhardt, 1915, p. 166—Friedmann, 1916, p. 321—Galli-Valerio, 1916, p. 41—Giese, 1915, p. 1274—Greene, 1898, p. 71—Heymann, 18. VIII. 1915, pp. 308, 318—Hönck, 1915, p. 368—Izar, 1916—Jeanneret-Minkine, 1915, pp. 132, 183—Kinloch, 1916, p. 789—Kisskalt, II. 1915, p. 154—Klemperer and Zinn, 1915, p. 324—Legendre, 1915, pp. 280–3—Lelean, 1917, pp. 201, 111–115—Noeller, 1915—Nuttall, unpublished experiments made in 1915–17—Peacock, VII. 1916, p. 55—Seligmann and Sokolowsky, 1915, pp. 962–3—Slammers, vide note in *Brit. Med. Journ.* VI. 1915, p. 986—Uhlenhuth, V. 1915, p. 533—Widmann, VIII. 1915, p. 293—Wulker, 1915, p. 630—Zueker, 1915, pp. 294–303.

Practical Section.

Regarding the methods of louse destruction by means of heat applied to clothing and effects[1].

1. *Dry Heat.*

Burning infested clothing is a method having but a limited application since it can usually be applied only to worthless objects. The old makeshift measure of passing a candle-flame or lighted match along the seams of clothing, thus *singeing* the fibres of the fabric to which nits and active lice adhere and causing them thereby to drop off, is a process which will only reduce the louse population temporarily since lice and nits are frequently hidden away in parts of the clothing which cannot be reached with the flame. Needless to say singeing cannot be often repeated without rendering the clothing unfit for wear.

Sun-baking may be resorted to where conditions are favourable, the clothing being spread out on the ground and occasionally turned about

[1] The terms *disinfestor* and *disinfestation*, in contrast to *disinfector* and *disinfection*, are used throughout in connection with louse destruction. A disinfector is necessarily a disinfestor since it destroys infective microorganisms like bacteria and their spores which are much more resistant than lice.

and inside out, the articles being afterwards beaten and brushed. How long the clothes will have to be exposed will depend on the degree of heat. In really hot dry climates the insects and their nits would probably be dead in a few hours. In cooler climates the exposure would have to be repeated on several successive days; a guide to the efficacy of the treatment would consist in the shrivelling of the nits and the decrease in the numbers of active lice[1].

A long familiar way of destroying lice by dry heat consists in the use of the *hot flat-iron*. It has been used on occasion in the armies of all the countries engaged in the present war. The larger the iron used the better for the purpose, tailor's irons being the best. The irons may either be self-heating or ordinary ones heated in any convenient manner. The adjoining illustration (Fig. 1) depicts a stove suitable for heating many irons at a time, the figure being taken from a sketch contained in Lieutenant Peacock's *MS. Report*, W.O. 1. 1918.

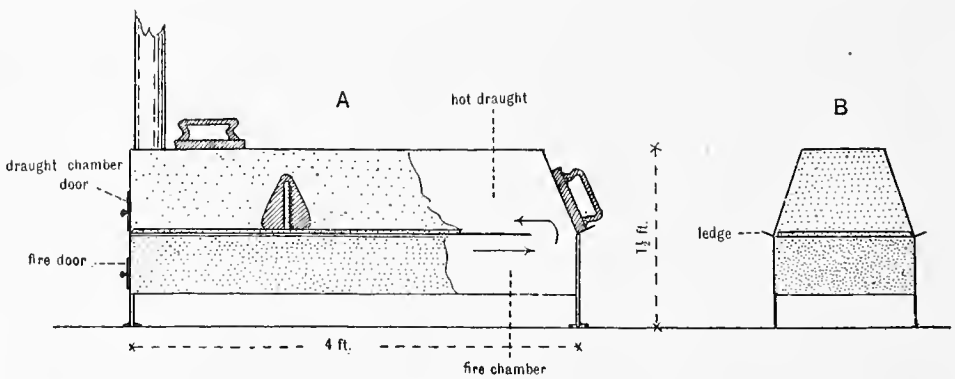


Fig. 1. Stove used for heating flat-irons. (A) viewed from the side and partly in section; showing the irons resting on top and on a ledge running along three sides. (B) viewed from one end. (Peacock *MS.*)

Ironing may be conveniently employed in cases where the infested clothing cannot be changed; it should if possible be applied once a week to all underclothing, uniforms, etc., special attention being paid to the seams, which should be turned back whilst the iron is run along them. Hot ironing does not shrink clothing and improves its appearance[2].

[1] Shipley (1914, pp. 497–9) states that sun-light kills lice, and that soldiers in the South African war turned their clothes inside out and hand-picked them in the sun, one of them describing the procedure thus: "We strips and we picks 'em off and places 'em in the sun, and it kind 'o breaks the little beggars 'earts." I apologize for adding that the effect of the sun's heat will usually be largely one of desiccation, the effect on lice corresponding to that which converts grapes into raisins.

[2] A dozen flat-irons are reckoned as necessary per battalion by Moor and Cooper, 1918, p. 55.

The objections to ironing as a means of disinfestation are: that it is not applicable where very large amounts of soldiers' clothing have to be treated; that it requires a large staff; that it takes a competent person about 15 minutes to iron each soldier's clothes; that the inexperienced ironer may scorch and injure the clothing; that the clothing requires to be handled a good deal in the process, it being likely that some lice will be scattered about and possibly picked up again on the ironed clothing or by those handling it. With these limitations, ironing constitutes an effective measure when conscientiously carried out. The ironing should be followed by beating or better by stiff brushing to dislodge dead lice. Insecticides may be ironed into seams (see p. 533, No. 411).

Hot rollers have been used in lieu of flat-irons in the disinfestation of blankets, but they are unsuitable for clothing, because of buttons, etc., besides which their use implies an expensive installation (Peacock *MS.*).

Another simple and perhaps equally effective measure has been suggested by Heymann (18. VIII. 1915, p. 314). It consists in wrapping the infested clothes around *tins containing boiling brine* (two handfuls of salt per litre of water) and covering them on the outside with tarpaulin. The brine boils at 108° C., and the temperature of the clothing attains 70–80° C. (see thermal death-point of lice, pp. 430–1). This method might very well serve a useful purpose under some conditions. To make sure that the requisite degree of heat has been attained within the clothing apply one of the methods described on p. 481.

Baking oven. The destruction of lice on verminous clothes by means of the baking oven is a very old method that has been widely used. The articles to be heated should be placed loosely in the oven.

The objections to the use of the oven are: that the number of household ovens is restricted and insufficient for army purposes, or where large amounts of clothing have to be periodically treated, that it is very difficult even for an experienced hand so to regulate the temperature of the oven that the contained clothing is not either scorched or insufficiently heated; that, as a German author remarks, it is not "appetizing" to bake bread in an oven that has previously been used for such purposes. Where, as Wulker (v. 1915, p. 630) reports from the German Eastern Front, the baking oven can be regulated at 60–70° C., it gives satisfactory results with the limitations mentioned.

Substitutes for the baking oven have been devised during the present war and a description of some of these constructions follows.

The essential points to have in mind are (*a*) that *hot air penetrates rapidly into fabrics that are loosely hung and amongst which it can circulate*, and (*b*) that *stagnant hot air penetrates very slowly into tightly packed fabrics*. These rudimentary facts have long been established by comparative experiments dating from the early days of disinfection, nevertheless they are persistently ignored, the result being oft repeated failures in practical disinfection with hot air or steam at atmospheric pressure to which these remarks equally apply.

Barrels or ordinary packing cases through which hot air circulates have served as fairly efficient louse destructors. In some cases the heat is made to emanate from a pipe traversing the disinfestation chamber from a flue beneath the floor.

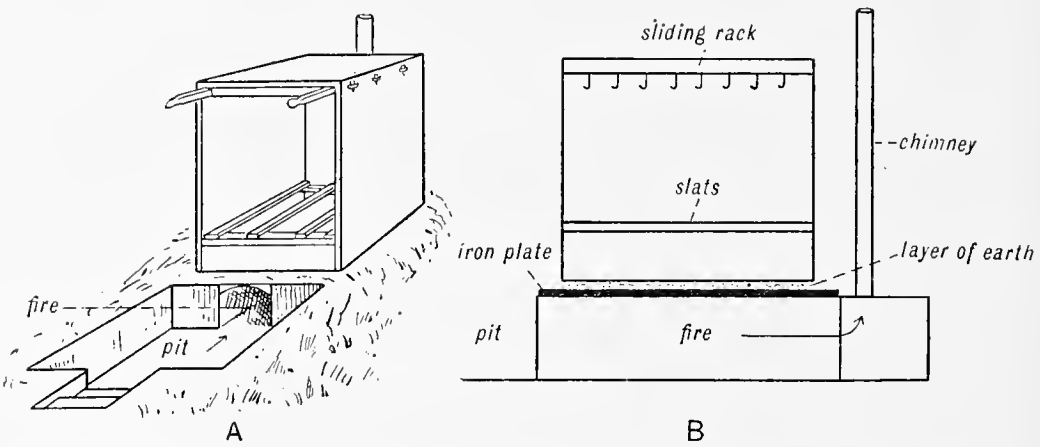


Fig. 2. Hot-air disinfesting box according to Rieck. (A) viewed in perspective when open. (B) longitudinal vertical section. Copied from the author's figure which omits the ventilator opening at the top.

Portable disinfesting box (see Fig. 2). This is a simple structure described by Rieck (1916, p. 1177) as follows:

Description: 1·5 m. long, 1·4 m. high, 0·85 m. wide; back, sides and top made of two thicknesses of crossed board; pasteboard separates the boards on top; walls held together by removable wedges as figured. Door, with wooden handles, held in place by wedges. Floor made of wooden slats attached a little above lower edge of sides. A simple frame with cross bars slides on side slats running along top and serves to carry 15 or more uniforms. Thermometer and ventilator are added on top for regulating the temperature. These parts being assembled, proceed to dig a front pit of ca. 1·5 cbm., continuous with a shallow trench. Lay three iron bars across trench a little below ground surface and rest a sheet iron plate (2 × 0·7 m.) thereon, putting earth around edge of sheet for box to rest on. Erect chimney at end of fire trench.

The box can be used in the open or elsewhere in a very short space of time. Even with the use of green wood, the author states that a

temperature of 110–120° C. (needlessly high) can be attained inside the box within 30 minutes. When once heated, and refilled, it warms up again to the required degree in a few minutes, even when the outside temperature registers 0° C.

Practical experience has shown that in all structures built on this plan it is necessary to *guard against the danger of scorching* the effects that are placed in too close proximity to the heated iron plate at the bottom of the box.

Hot-air pit (Bass, 1916). A pit is dug in the earth and shored up with rough timbers and roofed similarly and topped with tarpaulin or galvanized iron. The air is heated by a chimney that is separated from the heating chamber by sheet iron. The clothing is hung up in rows in the chamber. The latter may also be used for sulphur fumigation.

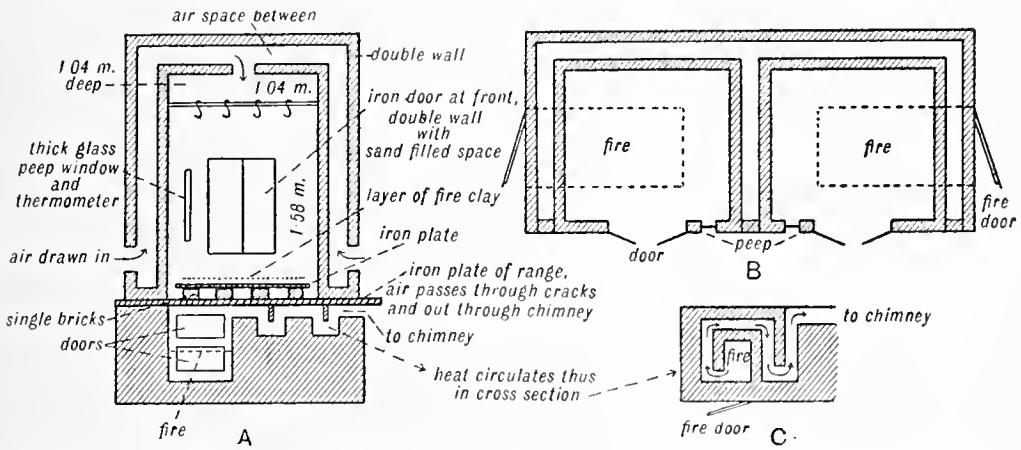


Fig. 3. Hot-air disinfestor according to Seligmann and Sokolowsky. This is built upon a kitchen range. (A) transverse vertical section and (B) horizontal section midway through the chamber. (C) horizontal section through smoke conduit beneath iron range plate.

Brick oven erected on kitchen range. Seligmann and Sokolowsky (1915, p. 962) describe a brick superstructure to a kitchen range which has been in use in all the hospitals of a Division of the German Eastern Army. The ranges in those parts project into rooms. A double-walled structure is built upon the top of the range, the walls being no thicker than the width of a brick and enclosing an air-space between them. The general plan is shown in Fig. 3 *A*. According to the authors, the oven costs ca. £2. 10*s*. to £3 exclusive of workmen's wages and it takes a day and a half to build. A temperature of 120–150° C. can be attained in the oven and its working capacity is 12 suits of clothing per hour or 144 per 24 hrs. at a calculated running expenditure of 1 Pfennig per suit. The ovens can be arranged in pairs (Fig. 3 *B*), in which case the fire doors

are best placed at the sides. As will be seen by reference to pp. 430–1 the temperature advised by the authors is altogether too high, since 65–70° C. suffices to kill vermin and the high temperatures mentioned injure fabrics (see p. 478).

This type of oven is based on a good principle in respect to the circulation of the air which is essential in rapid hot-air disinfestation. From Fig. 3 *A* it will be seen that the air is drawn in below at the sides of the oven and passes upward between the warmed outer and inner walls before it enters the chamber from above; it is then drawn downward escaping through interspaces in the range plate and passes out by being drawn up the chimney, the latter having a good draught.

Brick oven erected in front of a fireplace. Rudolph (1915, p. 863) describes an oven that may be built in front of any fireplace in a ground

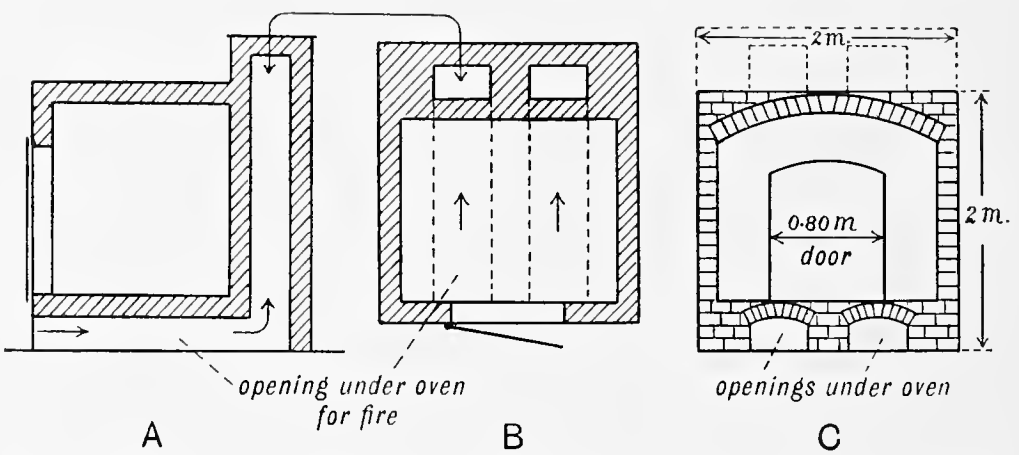


Fig. 4. Hot-air disinfestor according to Rudolph. This consists of brick with a metal door. (A) longitudinal vertical section. (B) horizontal section above the floor. (C) transverse vertical section.

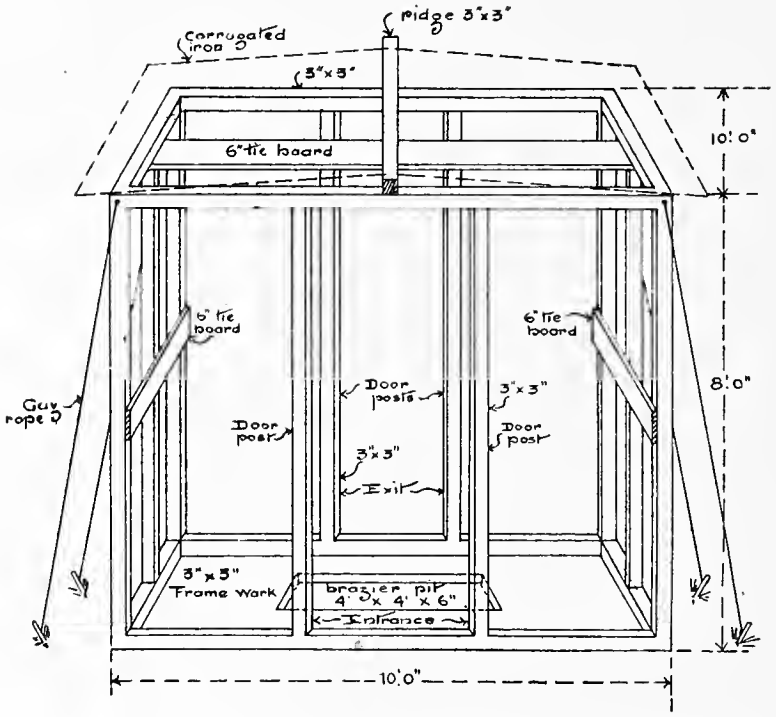
floor room (Fig. 4). It can be erected in a couple of days by soldier bricklayers using bricks collected in the vicinity. The temperature should not be allowed to rise so that it browns paper (a poor test indeed), it being necessary to guard against overheating during the half-hour's exposure period. Hooks or cross rails are fixed within the chamber for hanging up clothes and blankets. A whole company's clothing can be treated in a day. The staff required for running such an oven consists of a sergeant and three men.

Railway carriages heated by steam radiators to a temperature below boiling-point, the air having been previously partially exhausted, have been used in Germany since 1915 (Rose in *Med. Fortnightly*, St Louis, cited in Editorial, VI. 1915, p. 1251).

Hot-air huts. A plan I have advocated and which I am glad to say has been to some extent adopted, is the use of huts, or possibly double-walled tents for the destruction of lice by hot air. This method, which I suggested to Captain Orr in 1915, is suitable for base camps and offers many advantages in that large quantities of clothing, blankets, etc., can be conveniently handled at a time. *The air, heated to* 60–70° *C.* (higher temperatures not being required) *is made to circulate in the space*, either naturally through inlets and outlets or it is kept moving by fans. The objects are hung on racks or wires (Orr) or by means of hooks attached to these, *sufficient space being left between the articles to allow for the free circulation of air about and between them.* The huts vary in size according to requirements and they may be heated either by stoves, steam pipes, or, as Captain Orr found, by coke braziers in the manner presently to be described. Such structures are preferably built low and it is essential that they should be secured against loss of heat by possessing *double walls* enclosing an intervening air-space.

Captain Harold Orr, C.A.M.C., at Shorncliffe, having proved the efficiency of a makeshift hot-air hut built of corrugated iron, afterwards devised a very useful type of hut which was further modified in points of detail by Captain J. T. Grant, R.A.M.C. These huts are shown in the illustrations and descriptions that follow (Grant and Peacock's *MS. Report*, W.O. I. 1918). The erection of the huts is such a simple matter that, even for army use, it is unnecessary to consider the making of sectional structures of the kind.

Improvised hot-air hut (*Model A*, Figs. 5–7, Grant and Peacock, *MS. Report*, W.O.). A simple wooden framework, of the dimensions indicated in the figures, is erected with 3 × 2 inch timber and covered on both the inside and outside with canvas (Fig. 6), thereby forming *a double-walled canvas chamber* (Fig. 7) which is afterwards roofed with corrugated iron. An *air-space* 3 inches wide separates the two canvas walls. The chamber has two entrances, each closed by canvas roll curtains that are weighted below and fastened at the sides to the hut. As the hut here figured was erected in an exposed position, it was found necessary to anchor it by guy ropes after the manner of a tent. Two tiers of heavy wires running parallel to each other traverse the hut beneath the ceiling, the one tier running at right angles to the other. The wires serve for suspending blankets (Fig. 7) or clothing attached to hooks, hung on the wires. A horizontal sheet of iron, ca. 5 × 5 feet, suspended at the corners by four wires hanging from the roof, deflects the hot air rising from the glowing braziers beneath; it serves as a heat radiator and guard against



Figs. 5–7. Improvised hot-air disinfestation hut. Model A. (Grant and Peacock *MS.*)

Fig. 5. Front view showing the wooden framework and brazier pit.

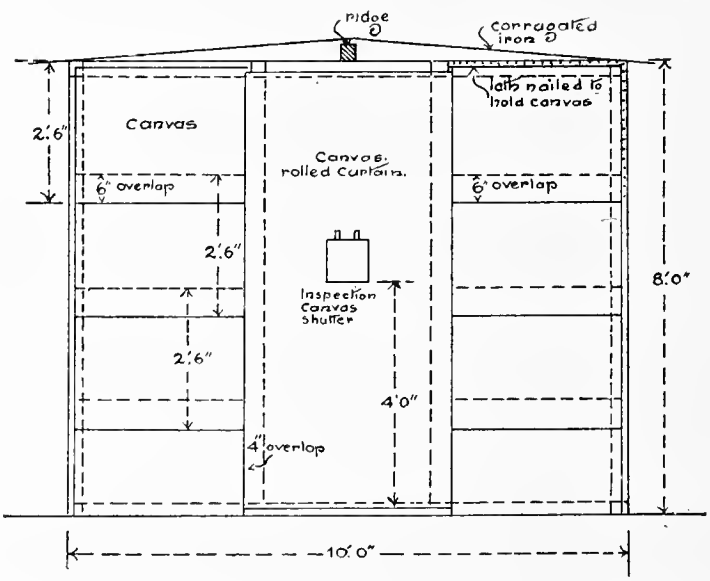


Fig. 6. Showing the manner of attaching the canvas and roll curtain.

sparks projected upward from the braziers which rest on bricks in the centre of the floor. The braziers (seen in cross section in Fig. 7) are simply made from 5-gallon oil drums, one side being cut away for a width of 8 inches; each end is held in place by 4 rivets, and 85 holes ($\frac{3}{4}$–1 inch) are punched in the metal, 20 holes being made at each end and the rest at the sides.

This hut, even when placed in an exposed position, was readily heated by the coke braziers, for whilst loaded with 60 blankets, the temperature inside attained 65° C. in 45 minutes. The 60 blankets are reckoned as equivalent to 200 pieces of underclothing, or 100 suits of

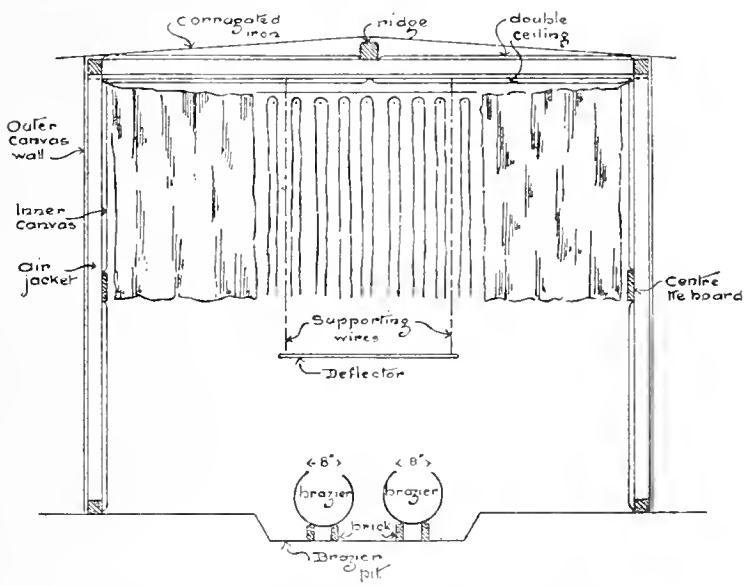


Fig. 7. Improvised hot-air disinfestation hut (Grant and Peacock). Vertical section showing the manner of suspending the blankets and iron deflector. The braziers are seen in cross section.

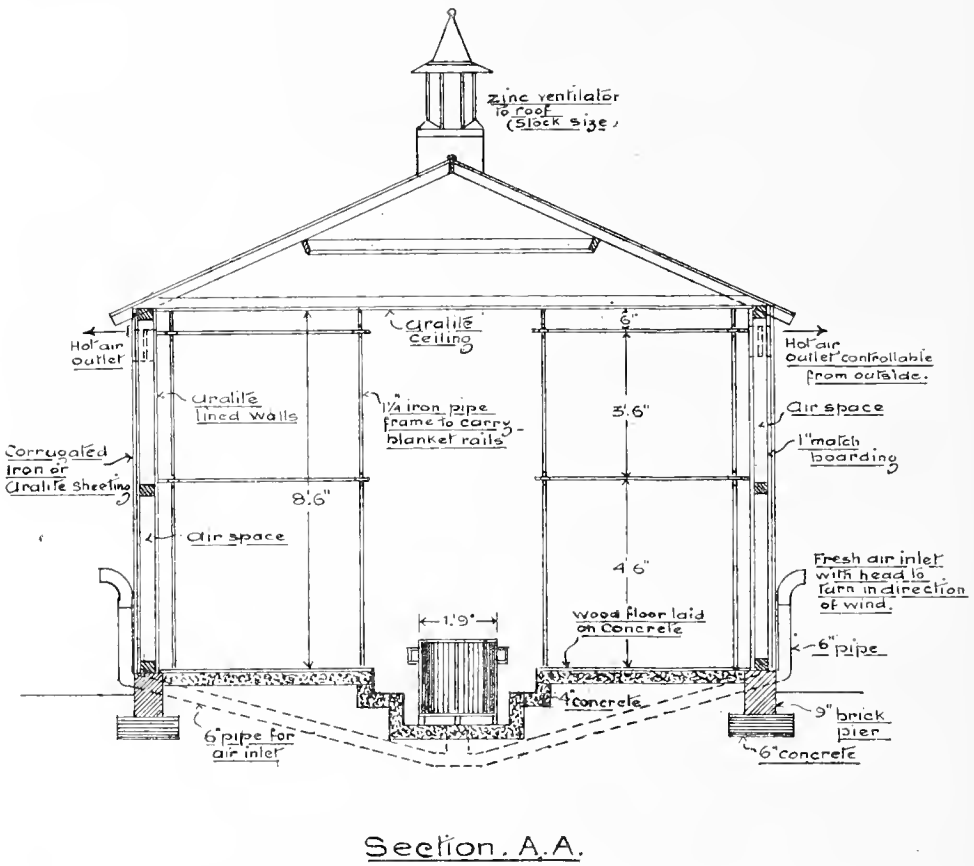
clothes, or 60 greatcoats. It was found best to hang the articles only in the upper part of the chamber as thereby the process of disinfestation was considerably shortened. In practice the hut dealt with fewer articles per diem if the heating was continued until the temperature near the floor of the chamber attained the degree requisite to kill vermin.

From what Lieut. Peacock told me last year, there must be a considerable air circulation through the walls of this hut for the canvas walls bulged out above and in below.

The time occupied in the various manipulations is reckoned as follows: loading (60 blankets or their equivalent) 15 minutes, heating

up and killing the lice 75 minutes, unloading 5 minutes, total 95 minutes. Reekon 15 minutes in addition for the first heating in the morning. Vermin in the heated chamber are exposed for a period of 30 minutes at 65° C.

A staff of 3 men is required to attend to the working of the hut; but the delivery, receiving, folding, checking, etc. of the articles handled require additional help.



Figs. 8–10. Hot-air disinfestation hut (Orr, *Model B*, modified in details by Grant).

Fig. 8. Section. Explanation in the text and figure.

Precautions should be taken against the inhalation of coke fumes.

Hot-air disinfestation hut (Figs. 8–10, Orr's *Model B*, modified by Grant)[1]. This hut is constructed on the same principle as the foregoing but is more rigid and provided with doors. The double walls are of uralite, or of uralite inside and corrugated iron outside, in place of canvas. The hut shows various improvements as follows:

[1] Condensed from description by Captain Grant (*MS. Report*, W.O. I. 1918)

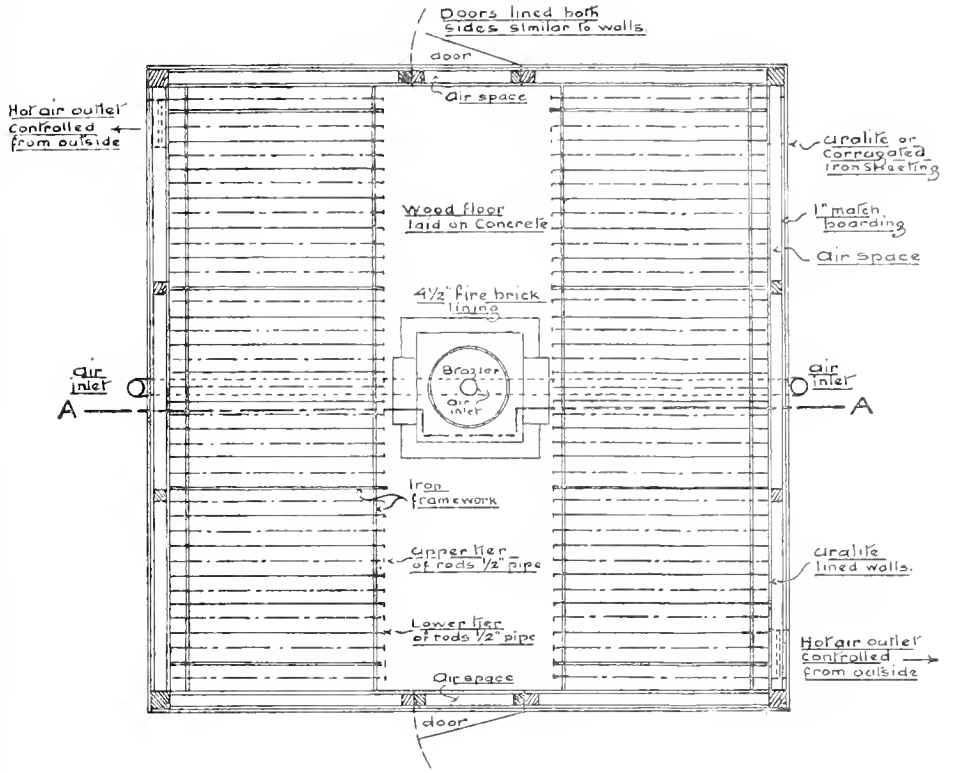


Fig. 9. Self explanatory.

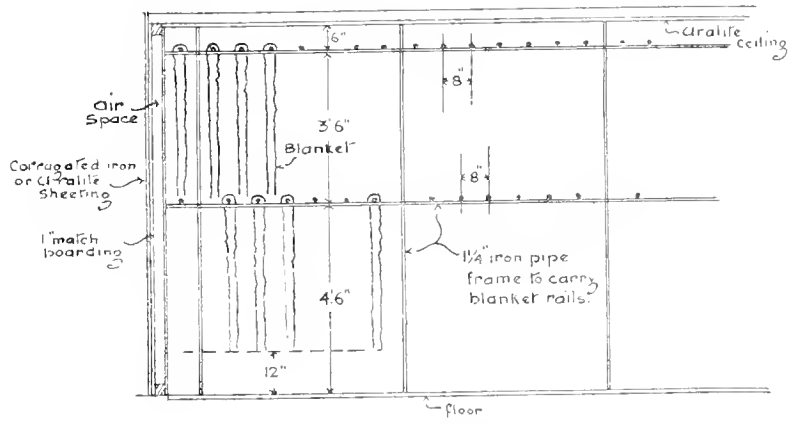


Fig. 10. Refer to the two preceding figures.

(1) Fresh air inlets entering the hut in the form of two six-inch pipes running beneath the floor and opening beneath the centre of a large brazier; the pipe openings are protected by guards against the infall of ashes from the brazier; the external openings of the pipes should have movable bent heads protruding 2 feet 6 inches above the ground. The bent heads can be orientated according to the wind so as to guard against gusts and excessive draught. (2) A ventilator in the roof, louvred or otherwise, prevents the air that is confined between the roof and ceiling from becoming overheated. (3) Two regulatable foul hot-air outlets are placed high up in the walls; they produce a much better air circulation in the heated chamber than when the opening is placed centrally in the ceiling. (4) A small plate glass window for reading the thermometer from the outside should be placed 4 inches from the floor. (5) Two tiers of bars or thick wire (Figs. 9, 10) run at right angles to the length of the hut, leaving a clear passage 4 feet 6 inches wide down the centre, the lower tier is placed 4 feet 6 inches above the floor so that a 7-foot blanket, hung thereon, does not come nearer than 1 foot from the floor. An interval of 8 inches should separate the bars of each tier. The bars of the upper and lower tiers should alternate, i.e., not be superposed (Fig. 10). A foot length of bar is reckoned per blanket. Sliding hooks on the bars serve for suspending uniforms, etc. (6) The brazier is placed in a well sunk 6–12 inches below the floor level. The floor and well beneath the brazier should be of firebricks or fire clay. It is an advantage in respect to heating to have the brazier as low as possible. (7) The floor can be made of concrete on sleeper walls with an air-space, or better still of coke brieze covered with $\frac{3}{4}$-inch flooring and protected by a sheet of iron opposite the door to guard against falling embers. This kind of floor economizes fuel and time in working, for the hut heats more rapidly if the floor be non-conducting.

Working capacity, etc. A hut of this kind, measuring $14 \times 14 \times 9$ feet high (1764 cubic feet) containing 60 iron rods 4 feet 8 inches long in two tiers, admits of a load of 300 blankets or their equivalent being treated at one time. Each blanket is folded lengthwise over a rod and is drawn slightly together along it, so that the blanket surface is puckered whereby 5 blankets are accommodated on each rod without being unduly crowded. The blankets of the lower tier should not approach closer than 1 foot from the floor as the lice may survive near floor level. It is therefore important in removing disinfested articles from the wires, that they should not be allowed to come in contact with the floor upon which lice may have dropped and remained alive.

It takes 2 men ca. 20–30 minutes to load the rods with blankets. The coke brazier, kindled about an hour before, is carried in and placed in position by two men. The exposure is timed from the moment when the thermometer 4 inches above the floor attains the desired lethal temperature for nits and lice (65° C.). The time required to heat the hut for the first time to the requisite temperature is 1 hour at least: on recharging and heating up again, it only takes 30 minutes to reach 65° C. The brazier consumes 40 lbs. of coke in the first heating and 20 lbs. in subsequent heatings when the hut is in running order. At the end of the exposure, the doors

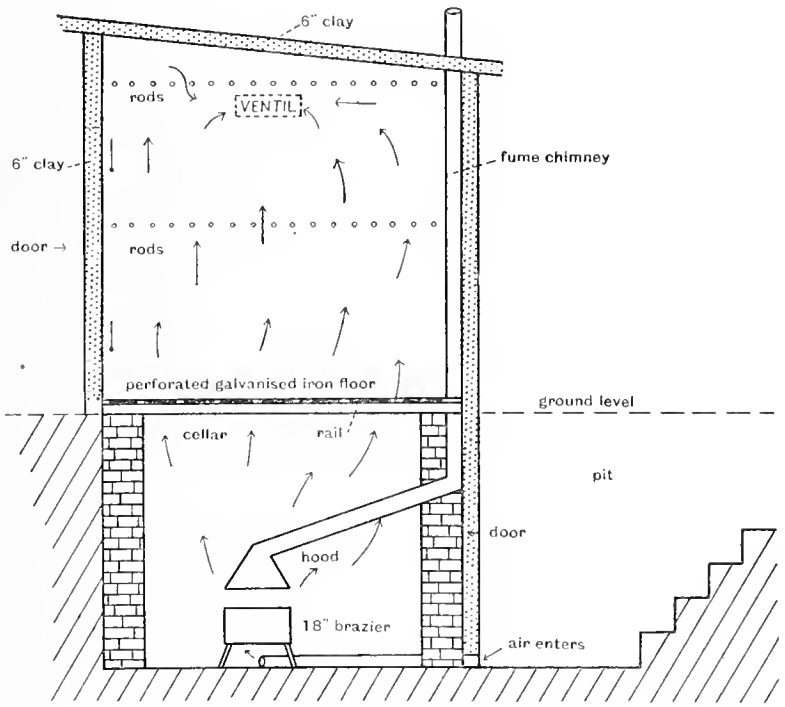


Fig. 11. Hot-air disinfestation hut designed by Captain Orr. *Model C.* For description see text.

are opened and the brazier is carried out, the chamber being ventilated and the contents removed, this occupying ca. 20 minutes. The men engaged should be warned against inhaling coke fumes. The floor of the hut should be washed down with cresol solution and swept with a stiff broom, or subjected to a steam jet after usage to destroy any living lice that may linger upon it. Buckets containing water and earth to serve as fire extinguishers should be at hand; Captain Grant has told me that conflagrations may occur if care is not exercised.

Orr's hot-air hut (*Model C*, Fig. 11). Captain Orr informs me

(III.–IV. 1918) that he has constructed two huts in France which, judging from his description and sketch plans, are an improvement on the foregoing Models A and B. Model C affords a better safeguard against conflagrations and doubtless distributes the heat more uniformly. Owing to the 6-inch interspace between the sheets of galvanized iron, forming the double walls and roof, being packed with clay, the structure is much better secured against loss of heat.

A corrugated iron floor (15 × 20, or 8 × 11 ft. in the smaller hut), perforated with numerous holes, separates a cellar-like space (6 ft. high) from the heating chamber proper (7 ft. high) which lies above. The iron floor is supported on 4 iron rails resting on brick pillars situated in the cellar. The floor of the cellar is below ground level; a door opens into the cellar and steps lead down into a pit fronting it. By this arrangement the braziers (2, measuring 18 inches across) may be served and removed at will without entering the disinfestation chamber. The latter is provided with bars suitably arranged (as in Fig. 9) for the reception of clothing or blankets. The air from the outside enters at floor level on either side of the cellar door and traverses two pipes ending beneath the braziers; the heated air traverses the perforations in the floor and escapes through two side ventilators in the walls of the hut after circulating in the space. The braziers are covered by hoods with flues leading to a chimney at the side whereby the excess of coke fumes escapes. The door to the chamber leads to a 4 ft. gangway between the two tiers of bars, the attendant treading upon a gang-plank resting on the iron floor.

Experimenting with the smaller hut (floor area 8 × 11 ft.) Captain Orr writes that when the outside temperature was 10° C., on first putting in the burning braziers at 2.10 p.m., the empty chamber attained 60° C. in 30 minutes, rising to 80° C. in $2\frac{1}{3}$ hours. When the doors were opened for 15 minutes, there was a fall to 46° C., but on shutting the door there was a rise to 67° C. in 20 minutes. By 8.30 p.m. the walls had evidently grown warmer, for on opening the chamber to cool it and again closing the doors, 70° C. was attained in 8 minutes, although the coke braziers had not been replenished whilst burning since 10 a.m. The braziers were still burning next morning, but owing to the dying down of the fires, the temperature had by that time fallen to 35° C. at 7.30 a.m. The braziers were now removed, filled, and reintroduced at 9 a.m., 64° C. being attained in 14 minutes. During this second day the chamber was repeatedly opened, cooled, and closed, it being found that it readily heated up to 65° C. in 4–6 minutes.

When the chamber was loaded with effects, it was found that it took twice as long to heat up as when it was empty. Starting at 38° C., after leaving the doors open for 15 minutes, 65° C. was attained 10–12 minutes after the doors were closed. The fumes from the coke caused no

inconvenience, for the braziers being removed and the doors opened, the chamber could be entered after the lapse of 1 minute.

Capacity and Consumption of Fuel. The larger hut is capable of dealing with the clothing of 50 men and 100 blankets at a time. Captain Orr compares the fuel consumption as follows:

Coal consumed by Thresh Foden-Lorry		Coke consumed by two braziers
110 lbs.	To start the machine or brazier	150 lbs.
70 lbs.	Subsequent consumption per hr.	0 for 12 hrs.

Jacobs' hot-air hut (*Model D*). This model was inadequately described by Captain Jacobs (II. 1918, p. 233) and I am indebted to Colonel Beveridge, R.A.M.C., for some further particulars concerning it. The chamber measures 15 × 15 × 7 ft. (high). The space between the double walls is filled with sawdust, and the floor cemented. It is heated by a cast iron stove having a heating surface of 1 sq. ft. per 100 cb. ft. (16 sq. ft. in the hut described). A perforated sheet of iron is placed above the stove, leaving a 3-inch space all round; it acts as a radiator. The outside air flows in by two pipes at the sides of the firebox, these traverse the combustion-chamber and deliver the now heated air into the chamber by openings 15 inches above floor level. After circulating in the chamber, the air passes down to four flues opening into the chamber but 7 inches from floor level and situated in the cavity of the double wall, whence it passes to a main exit shaft in the roof measuring 3 ft. across and twice the height of the building. The chamber has doors on opposite sides opening into corresponding rooms serving respectively for the reception and discharge of effects from the disinfestor. The effects are loaded on a number of racks which glide on wheels running on top rails on the same principle as in Vondran's apparatus (Fig. 13). To avoid loss of heat, the racks are not all pushed in at one time but in succession, and the door is opened and shut as quickly as possible. The temperature in the chamber is said to attain 60–80° C., but Captain Orr tells me that when he saw the hut working last winter, the weather being cold, a temperature of 70° C. could not be attained. Four men are required as personnel. According to Jacobs the hut is capable of dealing with the effects of 80 men at a time, the stove burning 7–10 lbs. of coal per hour. Details are lacking whereby to judge of the relative efficiency and cost of building and running Jacobs' hut and that of Orr, but Colonel Beveridge writes (IV. 1918) that several of Jacobs' huts are now in use and that they are efficient when properly handled.

Remarks.

In the foregoing methods of hot-air disinfestation there are two practical difficulties to be met: (1) the unequal distribution of the heat in the chamber, this being most marked in large and high chambers, the temperature below being much lower than above. The contrast in temperature will necessarily be greater in flimsy structures in exposed situations especially in cold weather. In the hut (*Model A*) used by Grant the floor and ceiling temperatures in two instances recorded were (*a*) 37° and 103° C. and (*b*) 68° and 120° C. respectively; therefore in practice the minimum lethal temperature should be registered in the lower part of the chamber. The difficulty can also be overcome by only exposing articles in the upper half of the hut as already suggested on p. 443 or by mixing the air in the chamber by means of fans driven by hand or otherwise. Judging from the plans alone, in the absence of recorded thermometric readings, the stratification of the air in the chamber according to temperature (hot above and cold below) should be less marked in Model C than in Models A and B, whereas in Model D, judging merely from the description, the temperature should be fairly uniform throughout the space, this being a most desirable feature. (2) If *moist articles* are placed in a hot-air chamber, they will be kept cool as long as evaporation continues, therefore they should be kept in the chamber sufficiently long (*a*) to become dry and (*b*) to be disinfested. In practice, dry articles are maintained at 65° C. (thermometer 4 inches from the floor) for 30 minutes, whilst damp articles are exposed for 60 minutes.

Captain Orr (22. IV. 1918) writes that it is impossible in damp weather to get rid of all the moisture in the chamber. He has sent me scale drawings of two new designs of huts which, while burning any fuel, are planned, most ingeniously, to ensure the adequate circulation of hot *dry* air in the chamber.

Incidentally, I desire to put on record that the credit for having first employed hot-air huts belongs entirely to Captain Orr, who erected and proved the efficiency of one built at Shorncliffe in the end of 1915. The tests subsequently carried out by Grant and Peacock were conducted with this identical hut.

Regular Apparatus.

Although not primarily intended for the purpose, all large jacketed steam disinfectors can be used as hot-air disinfestors if required (see footnote, p. 469). This is accomplished by admitting steam into the jacket only and allowing heated air to enter and circulate in the chamber as is

usually done in the drying process that follows upon the cutting off of the steam from the inner chamber after steam sterilization has been effected.

Vondran's apparatus constitutes a distinct advance in hot-air disinfection. In this apparatus *air heated either by a furnace or by electricity is forcibly propelled through clothing* and effects contained in a chamber. The heated air thereby overcomes the low heat conductivity of the clothing and expels the cold air confined in the interstices of fabrics, both of which factors render disinfection by stagnant hot air inefficient.

Experiments by Rautmann (1915)[1] led the engineer Vondran to perfect his apparatus. Rautmann found that he could disinfect leather, paper, catgut, etc., by this means. Kutcher (1916)[1], working with a small apparatus, found that typhoid bacilli were destroyed therein at 70–80°, but at times survived an exposure at 90° C. Baerthlein (1916, p. 527) worked with *a large apparatus that was used with very satisfactory results for destroying lice* at Czersk Prisoners' Camp. This apparatus had a capacity of 6·45 cbm. and was capable of dealing with 45 complete soldiers' kits at a time; it took 10 minutes to heat up to 80–85° C., this temperature being maintained for 25–30 minutes. Baerthlein found some spore-free bacteria to be capable at times of resisting 95–100° C. for 2 hours. Miessner and Lange (1917, pp. 329–365) on the other hand destroyed anthrax spores by an exposure of 2 hours at 125° C., but contrary to Rautmann they failed to sterilize catgut satisfactorily.

The discrepancies in the results above recorded are doubtless explained by the circumstance that *if the apparatus is incompletely or not uniformly filled, the air, following the course of least resistance, streams past the objects* and out through the chamber without penetrating them[2]. Moreover, as I have already noted (p. 450), damp effects must first become dry before they can attain the requisite temperature. The experimenters state that in a well-filled apparatus the objects near the hot-air inflow become more highly heated than those above, the difference between the top and bottom of the chamber at times amounting to 20° C. In the empty apparatus the temperature in all parts is very uniform, but a slight obstruction in the chamber upsets this uniformity. If the hot-air supply is cut off the temperature soon becomes equalized again in the chamber. The higher temperature of the fabrics situate near

[1] Cited by Miessner and Lange (1917, pp. 332, 333), originals inaccessible: Rautmann (1915), Untersuchungen über den Desinfektionswert stark bewegter, trockener Heissluft. *Centralbl. f. Bakteriol.* Orig. LXXVII. 56. Kutcher (1916), Prüfung des Vondran'schen Entseuchungsapparates, *München. med. Wochenschr.* p. 337.

[2] The same phenomenon may occur in steam disinfectors.

the hot-air inflow appears to me to be due to heat retained in the fibres and the infiltration of hot air into the meshes of the fabric, this infiltration gradually progressing until it attains the effects near the outflow.

The accompanying illustration (Fig. 12) explains the principle of the Vondran apparatus. *A* represents a vertical section with the blower (*b*)

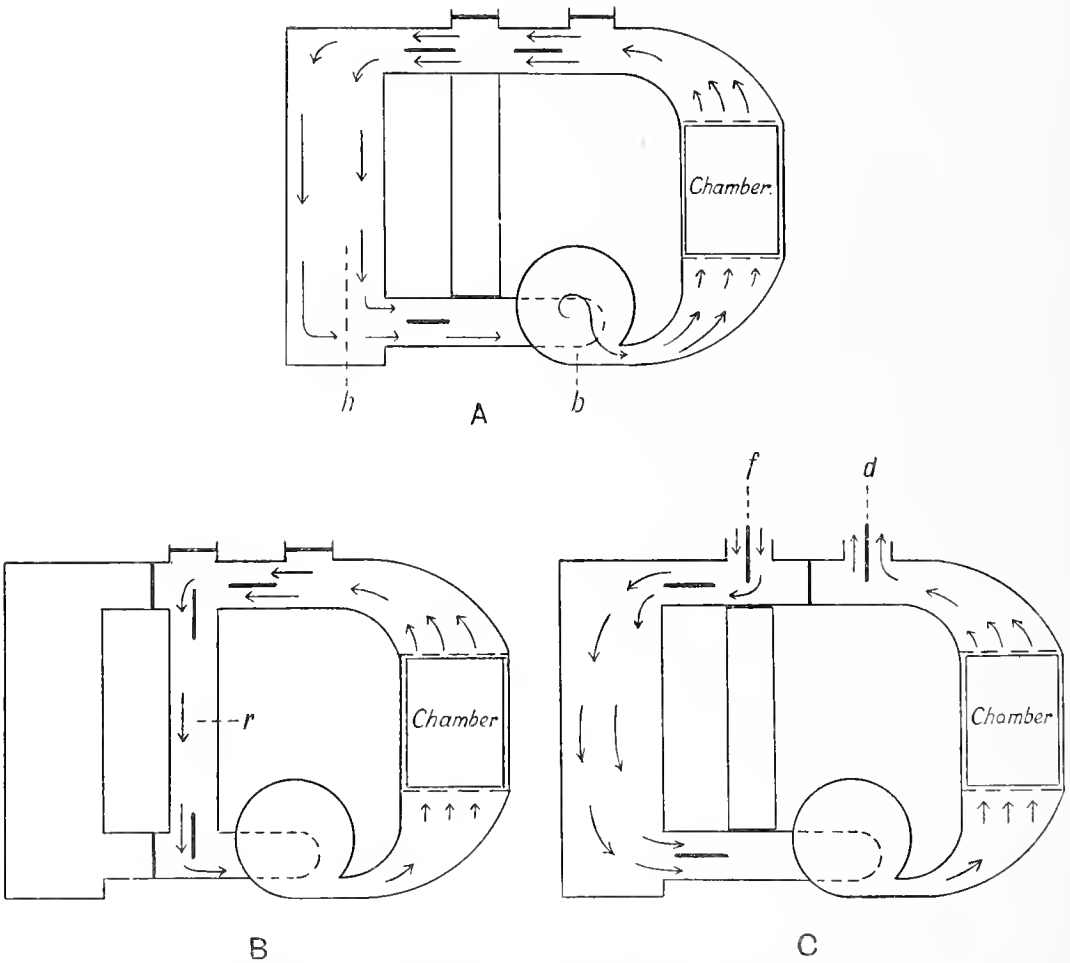


Fig. 12. Vondran hot-air disinfector. Schematic figures illustrating the general principle of the apparatus. Modified from Miessner and Lange (1917).

below which forces air into the adjoining chamber in which clothes, etc., are suspended; the air then pursues a course as indicated by the arrows, through a circuit and back to the blower on the side where it aspirates. By comparing the figures, various dampers will be noticed whereby the air current can be directed in different ways as required. In *A* the dampers are arranged while the apparatus is being first heated up.

The air enters the lower part of the chamber which expands like a funnel and passes out again above where the chamber again contracts, thence the air passes back to the hot-air shaft (*h*) which contains a coal-heated furnace and thence returns re-heated to the blower. A

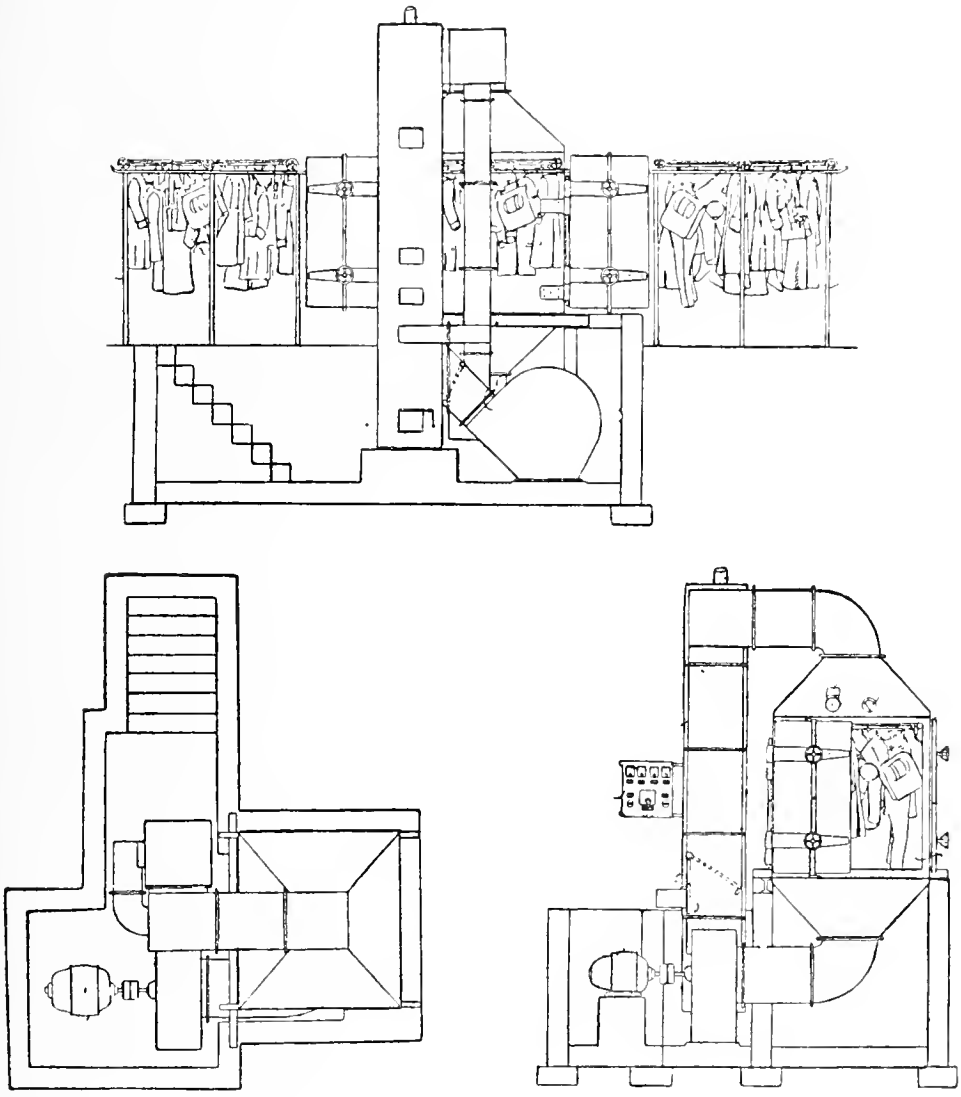


Fig. 13. Vondran hot-air disinfector. Large apparatus for disinfestation of clothing and effects. From Miessner and Lange (1917).

regulating or deviating shaft (*r*) connects the outflow and inflow shafts above and below, when the dampers are regulated as in *B*, thereby cutting off the shaft which supplies the hot air and regulating the temperature in the different parts of the apparatus. In *C* the dampers

are arranged to permit of a continuous inflow of clean hot air which serves to dry damp effects, the damp-laden air escapes at (*d*), and fresh air, aspirated into the apparatus at (*f*), passes through the heating shaft and thence to the blower and chamber. The size and power of the blower necessarily vary in accordance with the work to be performed.

Fig. 13, which is published by Miessner and Lange without explanation, illustrates a large apparatus in which the clothes, hung on racks, are run in and out on rails at the top. Although no doubt very efficient for louse destruction, the Vondran apparatus must be very costly. Whilst it appears suited for permanent installations, there is no doubt that simple and inexpensive hot-air huts heated by stoves, radiators or coke-braziers will answer equally well for military purposes. As pointed out in the passage I have italicized (see p. 451) the mode of packing the apparatus is important in respect to its efficiency.

2. *Moist Heat.*

(*a*) The Immersion of Effects in Hot Water.

The experiments recorded on p. 433 show that (*a*) scalding infested articles, or (*b*) dipping them into water at 70° C. for a minute or two, or (*c*) exposing them for 10 minutes at 55° C. will kill all the vermin they contain. Whilst granting Peacock's contention (*MS.* I. 1918) that it is best to dip underclothes in boiling water because most people have no thermometers wherewith to determine the temperature but understand what "boiling water" means, it appears worth noting that a lower temperature suffices for the purpose because of the injurious effect of high temperatures in causing shrinkage of some fabrics. There is no object in adding cresol or soap to the hot water unless the latter is employed for the cleansing of soiled effects.

(*b*) The Steam Jet.

From what has been stated on p. 434 the steam jet, when available, can be used effectively for killing lice on clothing or in disinfesting railway carriages and the floors of premises, etc., in place of insecticide solutions.

(*c*) Steam Disinfestation.

Improvised Apparatus.

The relative advantages of hot-air and steam disinfestation will be presently discussed (see p. 479). We may commence by considering the different types of steam disinfectors that have been used, beginning with the simpler improvised kinds that have been found effective in practice.

Professor Mary informed me in August 1915, that the campaign against lice began at an early date in the French army, a circular on the subject having been issued in October 1914 by Professor Roux and himself. He states that steam disinfectors were hastily improvised in various ways from materials at hand, stationary engines, temporarily disused camp kitchens on wheels, etc., being pressed into service. Very often two large wash-tubs, merely superposed, formed an efficient steam chamber.

Barrel steam disinfectors have been extensively employed in the present war, one type being commonly referred to among military men as "Serbian barrels" because they were apparently first employed in Serbia. When properly managed, the temperature inside of such barrels attains ca. 100° C. and they constitute about the simplest form of steam disinfector that can be devised. A 60 gallon barrel is capable of coping with 4 soldiers' kits or 7 blankets at a time. The barrel, having had its top and bottom knocked out, is provided with a grated wooden bottom and a flat wooden lid which can be weighted if necessary with stones. The barrel may be used in various ways:

(*a*) A short trench is dug in the ground of such a size as to accommodate a shallow circular boiler with adequate space for a fire beneath. The boiler rests on a couple of iron bars traversing the trench. The boiler should possess a diameter corresponding to that of the bottom of the barrel which rests on top of it. The top of the boiler should be flush with the ground surface or but slightly higher. It is well to smear the pit with clay, and to embed the barrel in clay, thus preventing the escape of steam where the barrel joins the boiler. A chimney is placed at the further end of the trench, thus completing the fireplace in which any available fuel may be burned. This arrangement may serve as a makeshift, but has drawbacks which need not be emphasized.

(*b*) The barrel rests on a boiler provided with a metal stand placed in a pit and surrounded by a dome-shaped layer of sand and tibbin or mud (Fig. 14 *C*). Lelean (1917, pp. 111–115) points out that this dome, combined with the pit, economizes fuel through checking needless loss of heat.

(*c*) A series of barrels may be placed in a row upon a narrow arched brick furnace (Fig. 14 *D*) provided with a chimney about 4 feet high at one end. The boilers, of the same diameter as the barrel bottom (ca. 18 inches), are set in the brick. Sand-bag collars at each end of the barrel impede the escape of steam from between the barrel and boiler and barrel and lid. Boilers having a smaller diameter than the barrel bottom

have been found inefficient since they do not generate a sufficient volume of steam in a given time. Lelean (*loc. cit.*) states that a hot fire in the furnace fills the barrels with steam in 40 minutes.

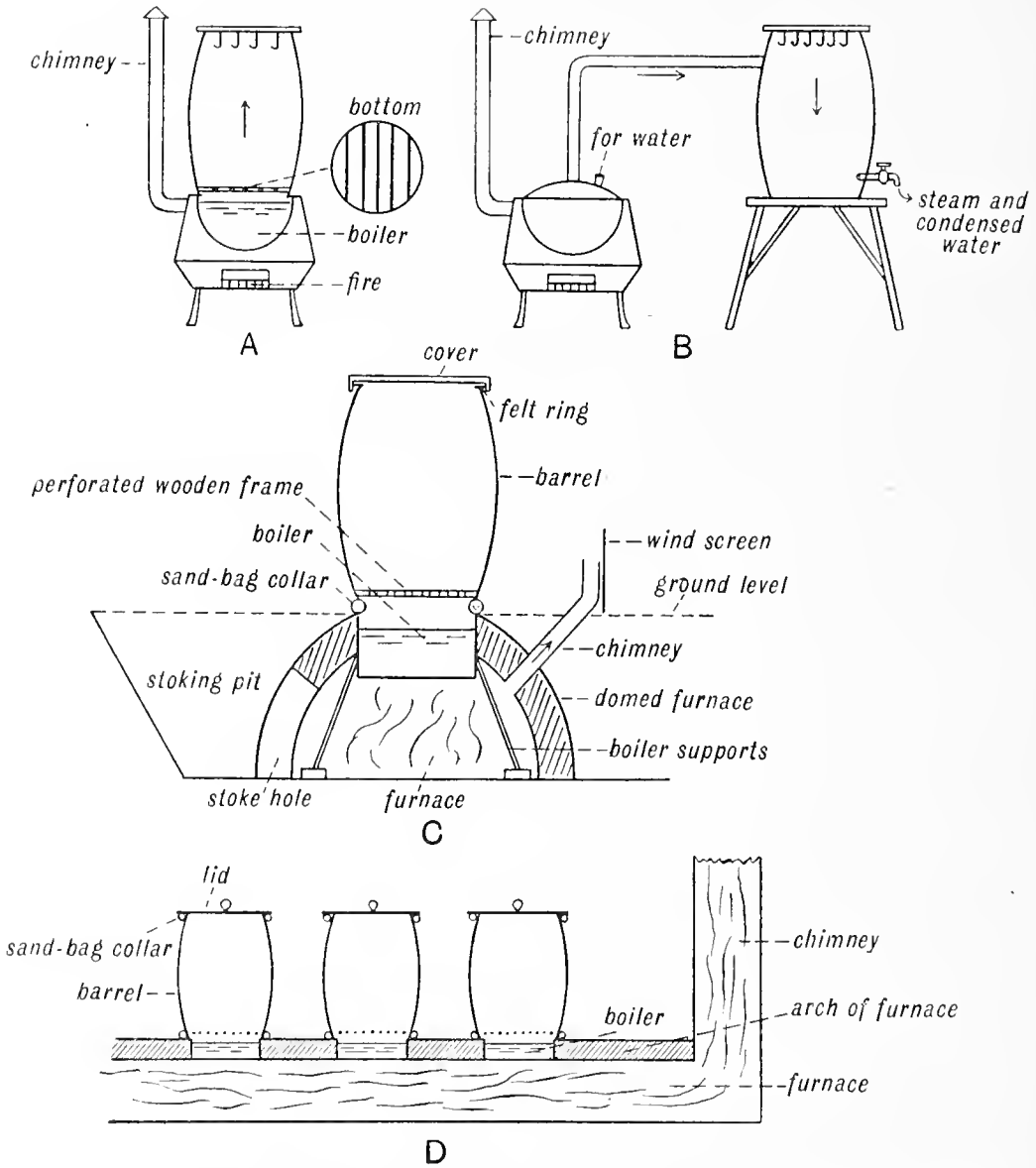


Fig. 14. Illustrating four ways of arranging barrel steam disinfectors. (*A* and *B*) according to Uhlenhuth and Olbrich, and (*C* and *D*) according to Lelean. For description see text.

(*d*) Whilst Teske (1915, p. 346) mentions the use of barrel disinfectors, Uhlenhuth and Olbrich (1915, p. 447) describe and illustrate two methods of using such barrels in connection with a general plan for

disinfesting troops on the German Western Front. In the first case (Fig. 14 *A*) the barrel is stood upon a boiler of corresponding size, suitable boilers of 125 litres capacity being commonly used in France for boiling cattle-fodder. The barrel-lid is provided with hooks on the underside upon which are hung the effects that are to be subjected to steam. Cracks and chinks are sealed up. When disinfection is completed, the lid is hoisted from the barrel by a rope and pulley thus removing the contents attached to the hooks. The disinfected clothing is best lowered over a partition wall or fence to the clean side of the lousing establishment.

(*e*) As some of the French boilers were found to be provided with lids, Uhlenhuth and Olbrich (*loc. cit.*) devised a simple method whereby steam from the covered boiler (Fig. 14 *B*) was led into the upper part of the barrel, this affording the well-known advantage of rapidly expelling the air from the barrel by the entering steam. In this case the bottom of the barrel is not removed, but a stopcock is inserted on one side below, whereby the escape of air, steam, and water of condensation is effected.

The disinfectors described under (*d*) and (*e*) must necessarily lose much heat if placed in exposed situations, but could be placed in a shed for protection. Otherwise the plans and descriptions incorporate useful suggestions. Fig. 14 *B* suggests the desirability, when possible, of using the same principle in the construction of larger disinfectors of a makeshift kind into which steam from any available source is conducted, the steam entering iron barrels, or tanks which may be made to serve as disinfecting chambers with the aid of a little ingenuity. There is of course nothing new in the principle described.

(*f*) Whereas in the foregoing cases the steam traverses the barrels at atmospheric pressure or, in (*e*), under a perhaps slightly enhanced pressure, Bordas (1916, p. 275) describes a simple apparatus used since the beginning of the war, in which the steam enters under pressure. The apparatus was found efficient and needed no repairs. Barrels from which the tops are knocked out, are lined on the inside with a spirally wound lead pipe of 20 mm. calibre, the pipe being 1 cm. distant from the inner surface of the barrel. Steam from a boiler enters the pipe above, under 6 kilogrammes pressure, and issues below through a stopcock. Two small holes, 0·5 mm. in size, are bored on the inside of the pipe at the last turn but one of the spiral near the floor of the barrel, the holes being situate at opposite sides of the spiral. A wooden cylinder, 6–8 cm. across, is stood vertically in the centre of the barrel, the objects to be disinfected being laid in around it, after which the cylinder is removed, thus leaving a central void. The barrel is covered with tarpaulin to act as a

lid. With an adequate supply of steam from an annexed boiler, the effects within the barrels attain a temperature of 105–108° C. in at most 35 minutes, and the clothing is dry on removal. The barrels are used in groups of 25 capable of disinfecting the effects of 500 men at a time. The size of the "battery" can be varied according to requirements, and reducing the length of the spiral pipe serves to lower the temperature attained within the barrel. The barrels may be mounted on a platform adjoining a railway station, on railway trucks, or on wagons; in the latter case extras may also be transported, i.e. water tanks and shower-bath sprays projecting at the sides where soldiers can cleanse themselves[1].

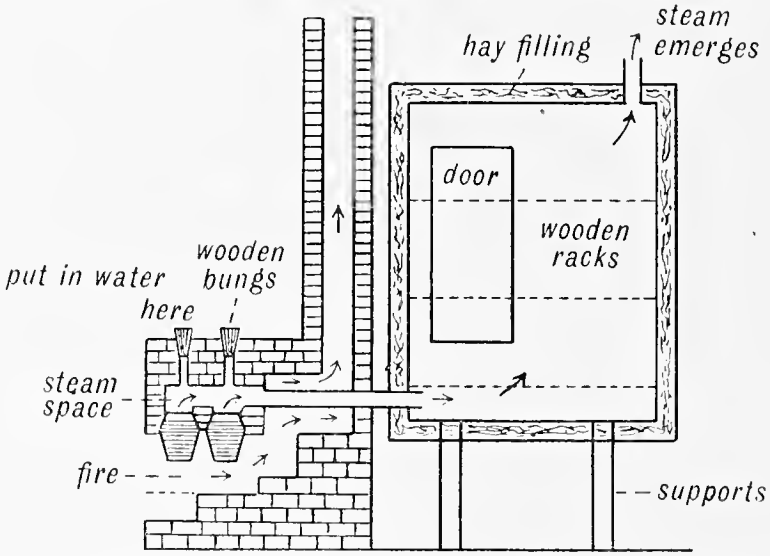


Fig. 15. Rischbieter's improvised apparatus for disinfection with superheated steam. For description see text.

Box steam disinfectors. Vago (1916, p. 240) devised a simple apparatus wherein steam under pressure was led into a disinfecting box and Rischbieter (1916, p. 30) describes and figures an improvised disinfector of a cheap and simple form that has been found useful at the German Eastern Front (see Fig. 15), superheated steam being employed.

This disinfector is used in the open and consists of two parts, (*a*) the steam generator and (*b*) the heating chamber. The generator is a brick structure with a chimney and fireplace, the latter containing two open

[1] The huge wooden barrels and vats, figured in German illustrated papers, measuring ca. 10 ft. across, the vats being provided with square doors fitted at the ends may serve either for steam disinfestation or louse destruction by gases, I cannot say which. They are shown resting on one side either on motor trucks, or, when on the ground, alongside what appear to be factory buildings. This form of disinfector is familiarly called a "Lausoleum."

iron boilers into which water can be poured by withdrawing the corresponding wooden bungs from the brickwork above them. The steam from the boilers is superheated as it travels along an iron pipe (lumen 7 cm.) in the back of the fireplace and bottom of the chimney to enter the heating chamber near its floor. The advantage in having two boilers is that one can be filled without checking the evolution of steam from the other. The heating chamber is a double-walled wooden box. The steam issues from its top at a temperature of 80–90° C. The space between the double-boarded sides (10 cm.) is packed with straw. A door, fastened by pegs, opens at one side into the chamber which contains wooden racks upon which clothes, etc., are hung. The heating chamber measures 1·2 × 1·5 × 0·7 m. and admits of the clothing, blankets and bedding of 6 men being treated at one time, the exposure lasting 50 minutes. The effects of 60 men can be disinfested in 10 hours.

Huts for steam disinfection. The drawback to the foregoing types of disinfectors is the small size of the heating chambers which, however, is to a certain extent compensated for by using them in groups or "batteries." Where a large number of effects have to be handled, it is a great advantage to have a larger chamber available.

Captain J. T. Grant, R.A.M.C. (*MS. Report*, W.O. xi. 1917), has described two types of huts which have been found very efficient in practice:

Type A (Figs. 16–19) is provided with a vertical boiler[1]. The structure is erected on a concrete platform 4 inches thick. The framework is of wood, covered on the outside with a roof and sides of corrugated iron and lined on the inside with uralite. The two-inch space between the inner and outer walls is occupied by air in preference to sawdust which tends to get wet and leads to loss of heat. A vertical partition, similar to the walls, divides the structure into two compartments each with a door opening outward; the one compartment contains the boiler, the other serves as a disinfecting chamber. A channel in the concrete floor conducts the condensation water outward. Radiator pipes (2 inch) run along the walls and ceiling of the chamber, steam entering them from the boiler, 6 horizontal radiator pipes running across the ceiling and 6

[1] Although augmenting the cost, it would be a material improvement to sink the boiler in a well as is usually done with boilers supplying radiators heated either with steam or hot water. The water condensing from the steam in the radiator pipes would not then have to be periodically drained off but would flow back by gravitation to the boiler. The size of the boiler will naturally have to be determined in accordance with the cubic space of the hut. In case galvanized iron is difficult to procure, a single layer of bricks may serve instead for the outer wall.

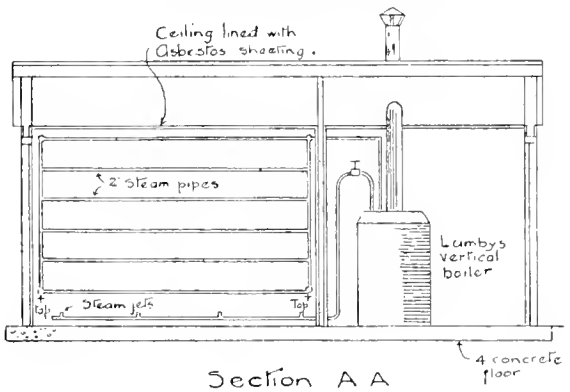


Fig. 16.

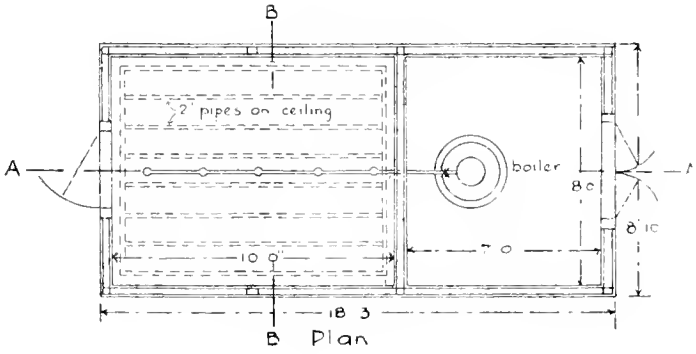


Fig. 17.

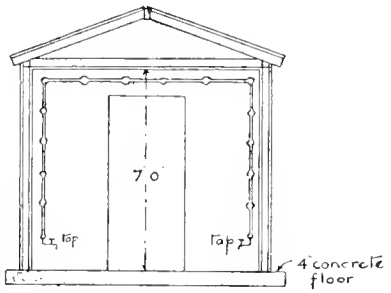


Fig. 18.

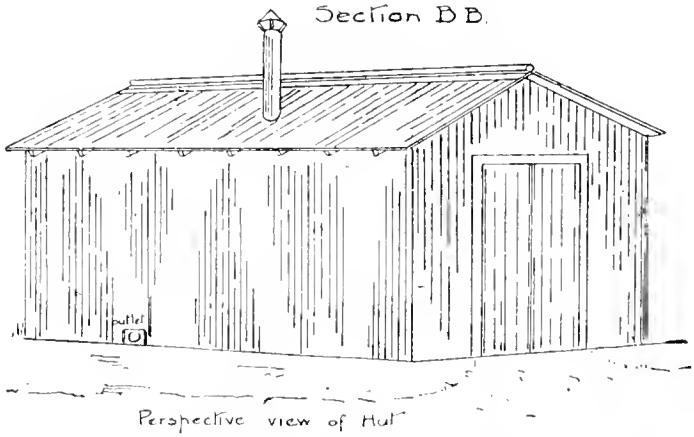


Fig. 19.

Figs. 16–19. Steam disinfection hut. *Type A.* Worked by vertical boiler. Vertical and horizontal sections, and in perspective. (Grant.)

along eaeh side wall; these pipes are provided with taps below for draining off water of eondensation. A seeond pipe from the boiler earries live steam down to a pipe on the floor, whenee the steam eseapes from variously direeted jets when a stopeoek near the boiler is opened. This pipe should have a stopeock at its lowest point for purposes of drainage, and the pipe should be fixed to the floor. A wooden grid (7×3 feet) rests 6 inches above the floor and serves as a gangway for those who enter the disinfeetor; it proteets the steam pipe and prevents the attendants' feet being wetted by eondensation water. The various dimensions are given in the plan, but a height of 6 feet 9 ineheS is preferred to that of 7 feet. A boiler with injeetor system is preferable to that figured. The door to the ehamber should have a eluteh handle and soeket for seeurity of fastening. A maximum thermometer wrapped in four thieknesses of blanket and plaeed down on the floor level was found to attain a temperature of 80° C. within 5 minutes.

A hut of this type is eapable of dealing with 200 blankets at a time or 1200 blankets per day of 6 turns. A staff eonsisting of 1 non-eommissioned offieer, 6 men and a boilerman is required. The eoal eonsumed amounts to 7 ewt. a week. The total eost of the plant was £65 in 1916.

Proeedure. The elothing or blankets are hung on 200 hooks attaehed on the radiator pipes beneath the eeiling. It is well to turn the elothing inside out. The ehamber is first heated by the radiators, steam is then allowed to enter gradually, the hut door being left slightly ajar for half a minute to faeilitate the expulsion of air from the ehamber by the steam. The door is then elosed and the steam is maintained in the ehamber for a period of 20–30 minutes. The ehamber door is now opened and the steam eseapes, the supply having been eut off from the boiler. Condensation water is drained away from the piping and the effeets are removed and shaken a eouple of times in the air to dry.

Type B. Paired huts (see Fig. 20) naturally aecomplish mueh more than a single hut, for the one may disinfeet whilst the other is being loaded or unloaded. A number of paired huts are being used in Franee ehiefly for louse destruetion. A threshing engine is used for generating the steam, but the latter may be derived from any suitable and available souree.

N.B. A hut of type A with wooden floor ean be mounted on a steam lorry, the steam from the lorry engine being used, or the hut ean be plaeed on a traetor tender (Grant).

Railway vans converted into steam disinfectors have been extensively used in the present war, espeeially in situations where large amounts of

effects have to be dealt with in a short space of time. Giese (1915, p. 1274) describes how this is effected by lining a wooden van with sheet iron, and sealing one door and all cracks with felt. Vertical wooden supports are screwed to the sides of the van and cross pieces are fixed across the top to support 16 lengths of old iron pipes traversing the width of the van near the roof. Along these pipes, which serve merely as rods, there slide galvanized iron hooks for suspending the articles to be disinfected. A row of pipes placed vertically down the middle of the van affords extra support to the pipes that cross beneath the ceiling. A *steam pipe* runs beneath the van and is covered with packing to prevent loss of heat; it has stopcocks, and two branches conduct the steam vertically up to near

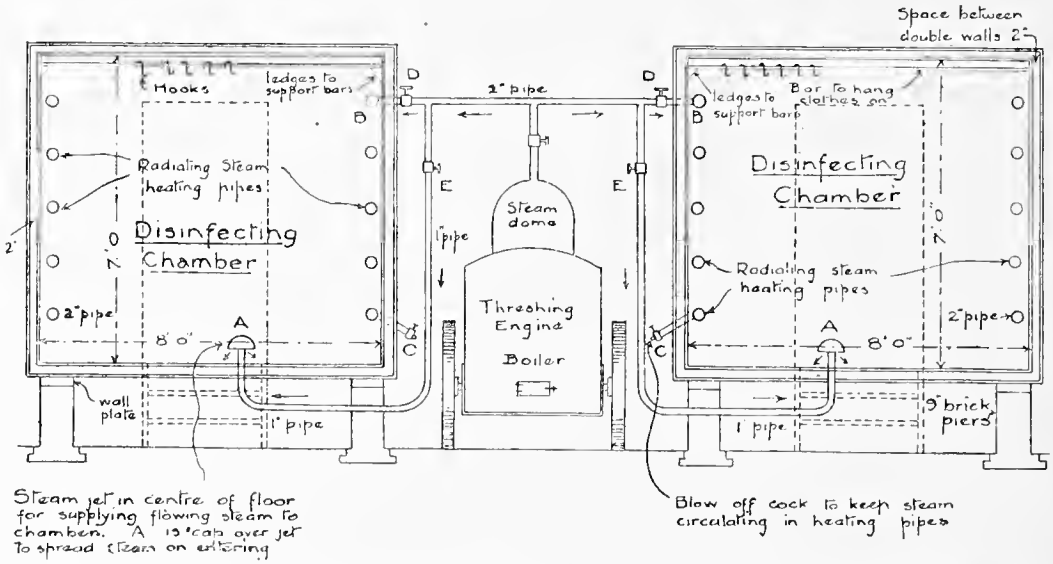


Fig. 20. Pair of steam disinfection huts. *Type B.* Worked by a threshing engine boiler. Transverse vertical section. Floor area 8 × 10 ft. The dotted lines indicate position of doors and steps up at end of hut. (Grant.)

the roof of the van so that the steam on entering the chamber expels the air downward. The air and condensation water escape through four holes at the sides in the floor, the holes being closed with wooden bungs by loosening which the outflow can be regulated. Inside, near the floor, are *radiator coils* protected by a slatted floor. Wooden slats cover the inner walls to prevent rust spots occurring on effects that might otherwise come in contact with the iron lining of the chamber. All iron pipes within the van are covered for the same reason. The door is made to close tightly by means of felt. The van is provided with a manometer and a thermometer which are visible from the outside. The steam for heating and sterilizing is supplied by the locomotive and, working with a

pressure of 4½–5 atmospheres, a temperature of 105° C. is attained within the chamber in about 30 minutes.

Procedure. After introducing the effects and closing the chamber, steam is turned into the radiators until the inside temperature attains 50° C. (dry), after which steam is admitted to the chamber until 100° C. is reached; steam is kept up for 45 minutes and then cut off, the radiators being allowed to act for 30 minutes longer. The effects are removed as soon as possible after the door has been opened, being taken out and shaken until dry, this being effected in a few moments. The preliminary heating prevents excessive condensation of steam on its first entry into the chamber and the final period of heating with radiators hastens drying. The author states that a railway van can be converted into a disinfector in the manner described, at a cost of 500 marks (£25).

Disinfecting trains may be stationed on sidings. Lelean (1917, pp. 111–115) states that two trucks 18 feet long will deal with the belongings (kit, greatcoat, two blankets) of 150 men per hour, and that four trucks would deal with the effects of a brigade in two days. Buchanan (1917, p. 21), likewise writing from experience in Egypt, refers to such trains as giving excellent results.

According to Lelean (1917, p. 208) such trains have many advantages, apart from mobility, over other installations: (*a*) "They are economical, for all clothing can be steamed, only one furnace is kept burning and the locomotive fetches its own fuel." (*b*) "Weight being no object, folding canvas screens and pipe systems can be carried and rapidly fitted to supply the shower-baths." (*c*) "The clothing can be rapidly dried in the trucks when sterilized." (*d*) "The number of trucks is easily increased, so that when required the train can deal simultaneously with one full regiment on either side, and thus de-louse a brigade in a couple of days." (*e*) "Being light, it can be drawn by an engine too decrepit to be of use for heavy military work, and so senile as to have one wheel in the scrap heap."

Through the courtesy of Major W. C. Smales, R.A.M.C., of the War Office, since the foregoing paragraphs were set up in type, I have been able to consult a *MS. Report on Disinfestation by means of Railway Van Disinfectors* by Colonel William Hunter, A.M.S. (dated 16. IV. 1917), who introduced the vans into Egypt in February, 1916. It appears that Lieut.-Colonel Stammers, R.A.M.C., when in Serbia, early in 1915, first used current steam from locomotives for disinfecting clothing exposed to its action in railway vans. Hunter, however, first brought the method into regular use, and by certain modifications in the manner of admitting

the steam into the chamber, greatly enhanced its efficiency besides shortening the exposure-time required.

Construction. The vans employed in Egypt are of iron but otherwise of ordinary form with double closely fitting doors at the sides. The steam from the engine is conducted through the ordinary couplings that are employed in connection with the steam heating of passenger carriages on railways, usually two vans being coupled to the engine. The steam main from the engine sends branches up to two parallel pipes about 4 feet apart running along and upon the van floor so that they are distant from the walls and leave a gangway between them along the centre of the van. These pipes are of large size and the steam escapes from them through *a double row of fine apertures* ($\frac{1}{8}$ inch) six inches apart and bored along the upper arc of the pipe. A light but strong wooden framework, whose supports rest on the floor close to the inner sides of the pipes, is built in the van to support three superposed shelves extending to the walls and running parallel to the length except where the doors open. These shelves are formed of slats about 3 inches apart and they serve for the reception of clothing. The steam leaves the engine at 6 lbs. pressure and consequently enters the chamber superheated, in great volume and with much force. The "heat of condensation" is considerable and the penetration rapid, so that when the chamber is loaded with bundles of clothing, even to overfilling, the heat penetrates quickly into the centre of the bundles. Within 5 minutes of turning on the steam, the exterior surface of the van wall can scarcely be touched because of the heat. The air and steam find apparently a sufficient escape through the narrow chinks at the door joints.

A temperature of 105° C. is attained in the centre of the largest clothes bundles or a rolled mattress within 30 minutes of turning on the steam; lice and nits are naturally found killed and shrivelled, for even potatoes placed in the middle of the bundles are cooked through in 30–40 minutes.

Procedure. The steps in the process of disinfecting the clothing, etc., of troops and prisoners of war are as follows: (1) The men parade, a company at a time, at intervals of 2 hours. (2) They remove all their clothes and remain dressed only in their greatcoats, caps and boots (articles made of leather, helmets, caps, waterproofs, ground-sheets and effects that include felt, glue or rubber must not be treated in the disinfector), all their other clothing being packed by them loosely in their two blankets tied up, with their identity discs firmly attached thereto. (3) The men parade and carry their bundles to the door of the

disinfeetor van where they are taken from them and stowed inside. The van is stationed at a railway siding. (4) Disinfection lasts 1 hour from the time the doors are shut and the steam is turned on, therefore during this time the men ean wash, bathe, wait, or return to their tents or huts if adjaeent, aeeording to eireumstances. (5) When the time is up the men return to reeeive their kits, the steam having been eut off and the doors of the van opened. At first the elothes are too hot to be touehed but they soon cool sufficiently to be handled. (6) The bundles are now handed out to the men who undo them quickly and shake the eontents for a minute or two in the air whilst warm, thereby drying them completely so that they can be worn 5 minutes after their removal from the van. (7) The men take their overcoats with identity dises attaehed to the van door, where they are reeeived and placed loosely on the shelves. (8) The disinfection of the coats only takes 15 minutes and they are returned to the men. (9) The men return to eamp with their kits and overcoats disinfeeted 2 hours from their arrival at the disinfeeting station.

Steam disinfestation of whole barracks. Blumberg (1915, p. 837) after stating that in dealing with 10,000 prisoners he found even large steam sterilizers (5 ebm. eapaeity) too small, and disinfecting vans (50 ebm.) being needed elsewhere in eonneetion with the war, reports that he determined to turn steam from several large stationary engines direetly into the barracks, leaving all the prisoners' effeets therein. The engines delivered steam at 6–7 atmospheres pressure, the temperature of the steam being 157·9–164° C.

Trials were made in briek buildings having a capacity of 1200 to 2650 cbm. The rooms were first heated up to 32° C. by several large ovens, the windows being sealed and a layer of earth 5 cm. thiek being placed on the roof (wood and felt) to lessen loss of heat. Iron tubing 290 m. long or more and of 58 mm. ealibre was placed around the room at a distanee of 25–45 cm. from the floor; the pipes were perforated with 8000 small holes (3 mm.) from which the steam could eseape. Eleetric and contact thermometers were plaeed in different parts of the room, and test-liee were variously distributed. Steam was allowed to enter for 6 hours, a temperature of 71–76° C. being maintained, after which the steam from the engines was eut off, the windows opened, etc. The clothing remained dry and all the liee were dead and brown or mummified.

Blumberg subsequently found that he eould simplify the proeess by omitting the preliminary dry heating and letting the steam enter direetly into the barracks even when the outside temperature registered 0–12° C. The main steam pipe from the engine only penetrated a distanee of 10 em. into the spaee. Powdered peat was used for sealing up craeks, and box-like wooden shutters were plaeed over the windows. Steam let

into wooden barraeks of 4000 ebm. capaeity in the manner described, raised the temperature to 78–96° C. within 2 hours either in winter or summer. He found that any boiler delivering a suffieient volume of steam answered the purpose as well as a stationary engine.

Blumberg adds in a postseript that a stationary engine having a heating surface of 21 square mètres, working at a pressure of 12 atmospheres, when it delivered steam into a wooden barraek (eovered all over with felt) of 600 ebm. eapacity, eonverted the barraek into an effieient disinfector, for it was capable of dealing with all the belongings of 700 prisoners or 1300 uniforms at a time, a temperature of 120° C. being attained inside the barraek within 1–3 hours. He therefore reeommends the construction of two sueh barraeks served alternately by one engine. The author states that by this means he has rid the prisoners at Brandenburg of lice.

Comments.

We may now conclude the deseription of improvised methods of disinfection and disinfestation, and eonsider the more perfect maehinery supplied by firms dealing in such apparatus. It will be at once seen that in faee of the great demand due to the war, and the neeessity of dealing with enormous amounts of infeeted artieles, that these forms of apparatus ean only cope in a small degree with the demands that are made upon them. Whilst admirably adapted for long eontinued use under the peace eonditions in whieh they were evolved, their eost[1] and the sudden demand upon their produetion render it impossible in many cases to employ them. It is beeause of the many emergeneies that have arisen in the eourse of the war, where requisite apparatus had to be quiekly improvised on the spot, that so mueh stress has been laid on makeshift methods, espeeially those designed to deal with lice. The high standards of effieieney attained by regular disinfeetors on the basis of their eapability of dealing with baeteria or their heat resisting spores do not appear neeessary for mere louse destruction. Elaborate apparatus is wasted on liee whieh are readily dealt with by simpler means and lower temperatures. Nevertheless an apparatus whieh ean fulfil every demand is always to be preferred if obtainable.

[1] Captain Grant (*MS. Report*, W.O., 1918) states that the horse-drawn Thresh costs three times as much as a steam hut (*Type A*, p. 459), their relative capacities in terms of blankets being as 36–40 : 200. Whilst the "Ibis" Disinfector, delivering 60 blankets an hour, is stated to eost £288.

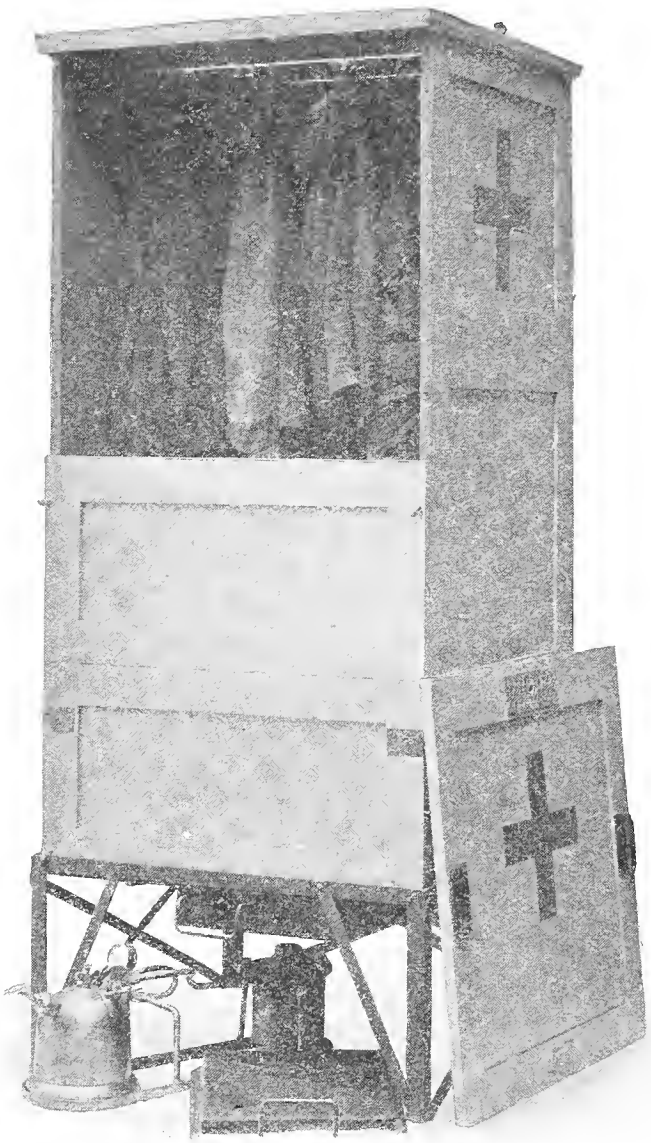


Fig. 1. The "Newman" Portable Disinfector, size No. 3, ready for closing and starting, the water pan in place and the baffle plate resting below on the floor.

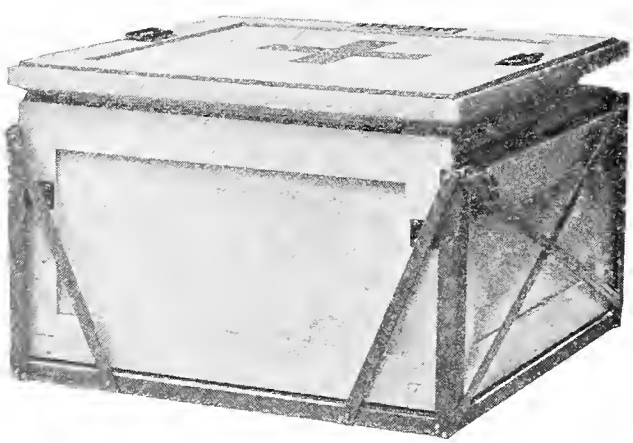


Fig. 2. The same as the foregoing, closed for removal and transport. It now measures 2.9 × 2.9 × 1.6 (feet and inches).

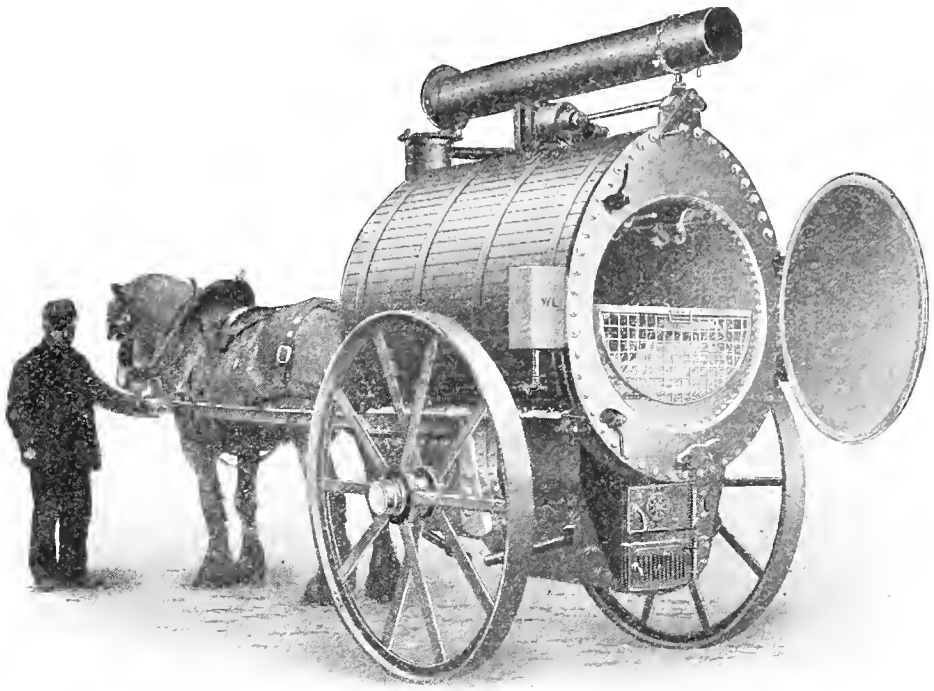


Fig. 3. Horse-drawn Thresh Steam Disinfector, furnace heated. Two wheeled type. The chamber measures 3 feet wide by 5 feet deep ($35\frac{1}{2}$ cubic feet).

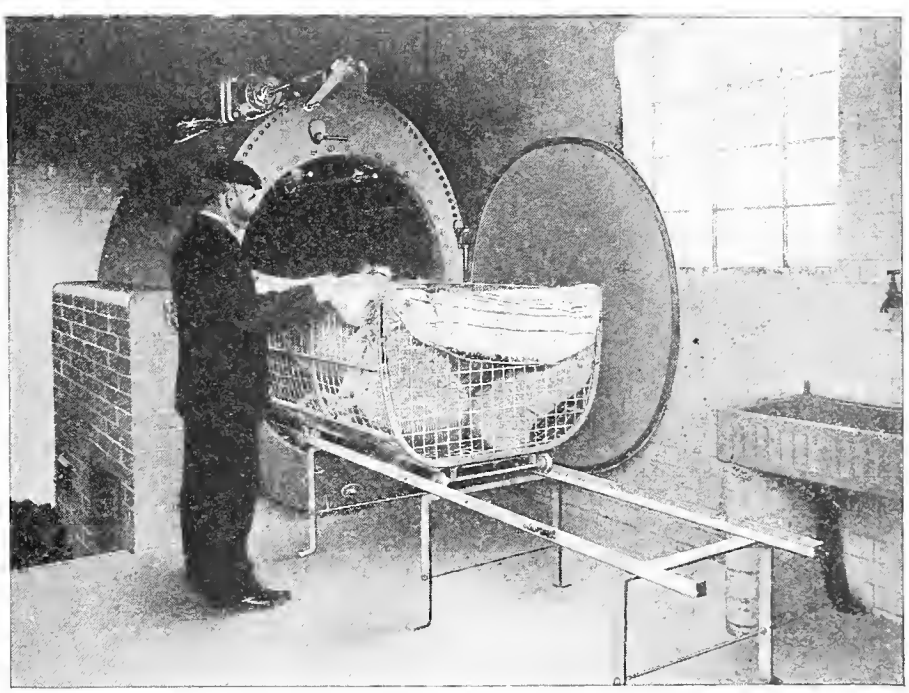


Fig. 4. Thresh Disinfector, fixed type, suitable for hospitals, etc. The chamber measures 3 feet 6 inches across by 4 feet 6 inches in height, the depth ranging up to 8 feet.

Regular Apparatus.

Portable Field Disinfecting Boxes (Fig. 21) have been extensively used by the British Army in the present war. These boxes are made of wood lined with zinc and felt, and steam is led into them from above at the side through an iron pipe and flexible tube emanating from a separate wrought iron boiler which can be placed on an improvised fireplace. Each box weighs 400 lbs. complete with boiler, and is capable of dealing with 6 soldiers' kits or 8 blankets at a time, the exposure to current steam lasting 30 minutes. The boxes can also be used for disinfection by formalin.

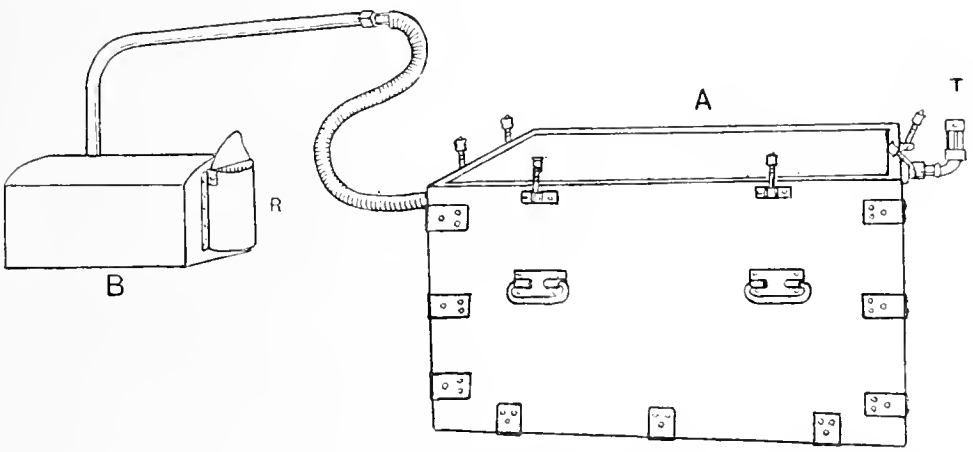


Fig. 21. Portable Field Disinfecting Box ("Disinfector, Steam Portable, box pattern, Mark II." Illustrated by permission of the War Office) as used in the British Army. (*A*) The box with lid removed. It measures roundly $3 \times 3 \times 1{\cdot}8$ ft. (height) externally when closed, being made of $\frac{7}{8}$ in. wood dovetailed at the corners, and lined with zinc covering cow hair felt; a strip of white felt along the edge ensures tight closure when the lid is bolted down by eight hinged thumb-screws. In a later model than the one here figured, the thermometer (*T*) is placed 4 inches above the lower margin and the box is divided into two compartments by a vertical partition, iron gratings, resting on slats occupying the floor of each compartment. The steam enters above at one side and escapes through a narrow slot ($10\frac{1}{2}'' \times \frac{5}{16}''$) near the bottom on the side adjacent to the thermometer. The boiler (*B*) measures roundly 1 ft. $9'' \times 1$ ft. $2'' \times 10''$ (height), a side receptacle (*R*) is provided for filling it by lifting the lid as figured. The steam pipe leading to the box measures 3 ft. in length.

The "Newman" Disinfector (Pl. X, Figs. 1 and 2)[1] is a simple, inexpensive current steam disinfector possessing the advantage that it can be folded and quickly packed in a small space for transport. It consists of an upright wooden box whose walls are held together with thumb-screws.

[1] London Warming and Ventilating Co., Ltd, 20 Newman Street, Oxford Street, London, W. 1.

It rests upon a wrought iron stand and is heated by means of an oil lamp. The box is lined with zinc covered interiorly with felt and there is a wire grating above the perforated iron bottom. The apparatus is suitable for small institutions, and is made in three sizes, Nos. 2–4[1], the chambers measuring respectively 2 ft. 1 in. × 2 ft. 1 in. × 5 ft. (high) in No. 2, 2 ft. 7 in. × 2 ft. 7 in. × 5 ft. 3 in. (high) in No. 3, and 2 ft. 9 in. × 2 ft. 9 in. × 6 ft. 5 in. (high) in No. 4, their weights, when packed, being 266, 378 and 406 lbs. respectively and the cost ranging from £18. 10*s.* to £35 (at pre-war rates).

The articles to be disinfected are hung upon hooks sliding on bars across the top; the articles should not touch the walls of the chamber for

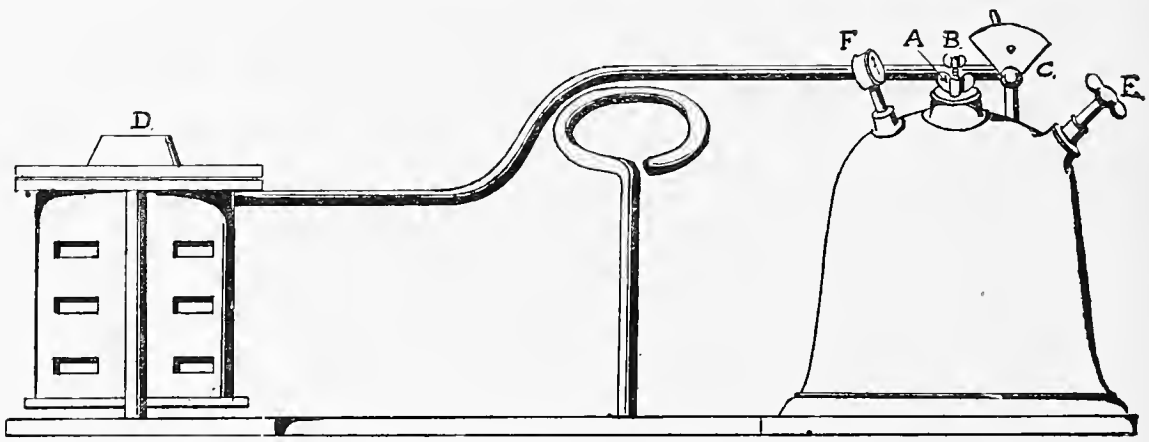


Fig. 22. Oil lamp belonging to the "Newman" disinfector. For description see footnote 2 below.

this would lead to their becoming wetted by water of condensation. An iron tray containing 1½ gallons of water and sliding in grooves beneath the box is placed in position and the box is closed. The lamp (Text-fig. 22) is of a well-known pattern[2], its flame should play upon the centre of the tray causing the water therein to boil quickly. When current steam issues from the small sliding grating near the top (in front), the latter should be half closed. The heating is now maintained for 30 minutes, after which the tray is removed and replaced by an iron baffle plate, and

[1] "No. 1" is only intended for disinfecting books, etc., by formalin.

[2] To use the lamp or oil furnace (1) unscrew *A*, nearly fill reservoir *E* with clean paraffin oil, grease the screw and screw down *A* and then *B*. (2) Pour two tablespoonfuls of methylated spirit into firebox *D* and ignite it, thereby heating the coil in 2–3 minutes. (3) Turn on supply-valve *C* slowly and regulate as desired. (4) Pump air about six times into reservoir *E* until gauge *F* registers 20, thus starting the machine; additional pumping increases the flame. If the burner becomes choked with dust or carbon, clear it with a wire or needle.

Fig. 5. Horse-drawn Thresh Steam Disinfector in action in the field.

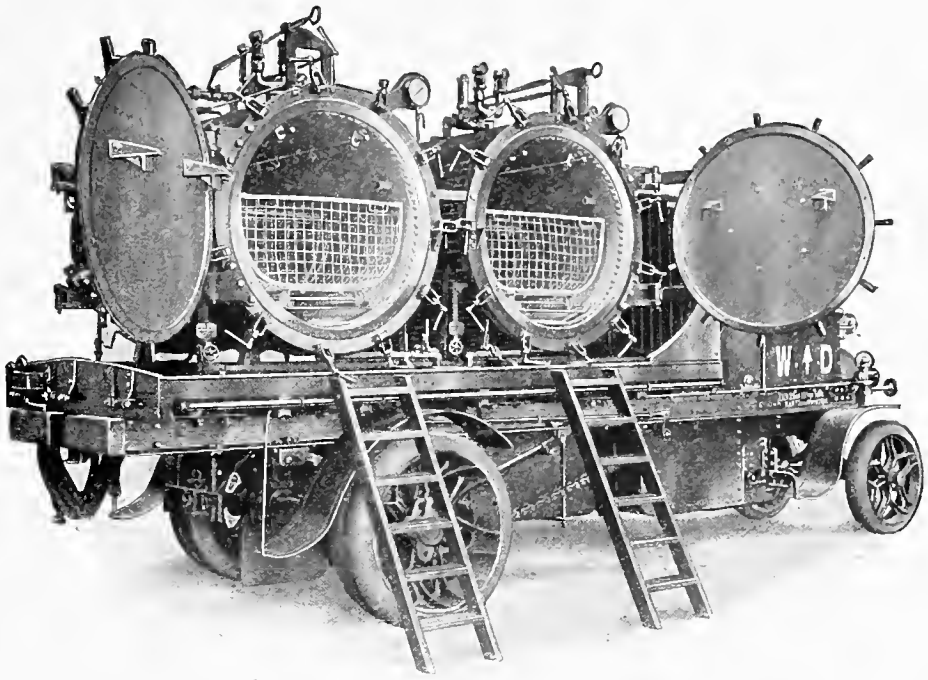


Fig. 6. Thresh Steam Disinfector on 5-ton Foden Steam Lorry. Each of the two chambers measures 3 feet 7 inches across by 6 feet deep (60 cubic feet).

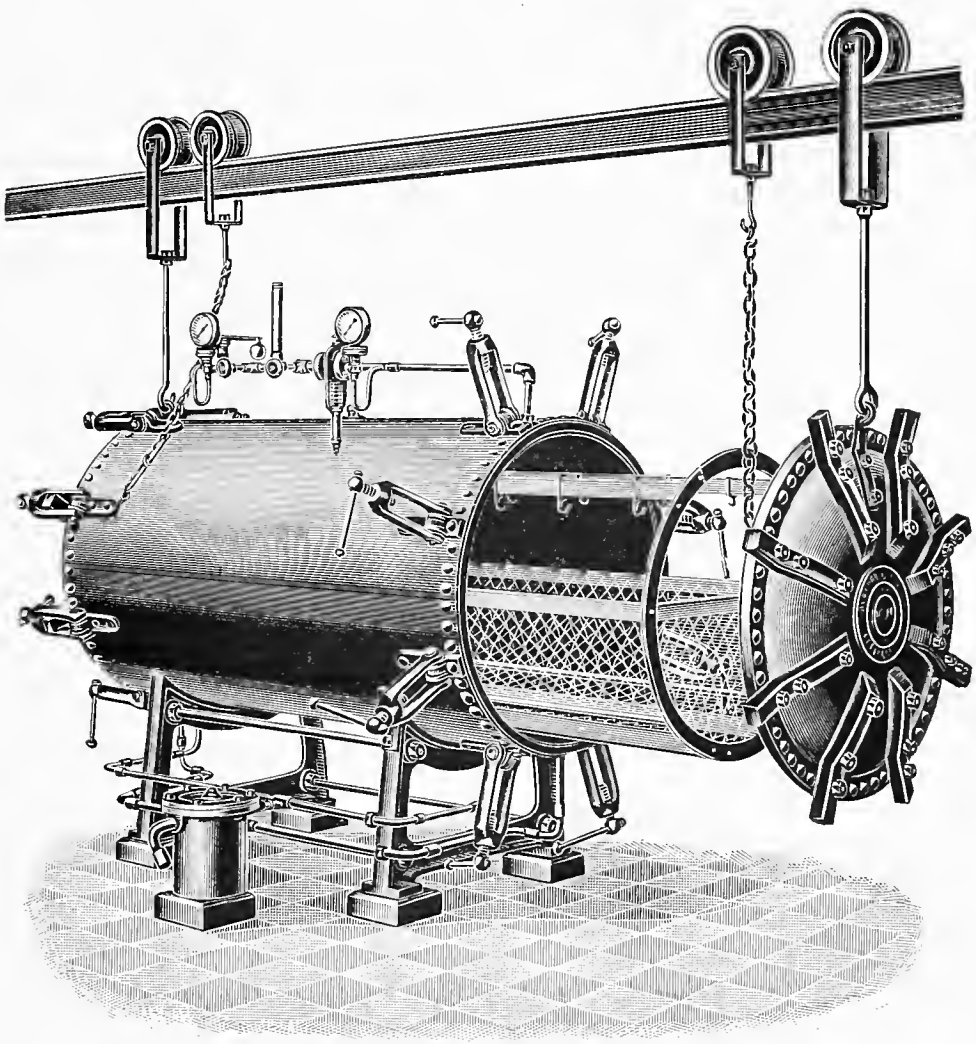


Fig. 7. Washington-Lyon Steam Disinfector. Made in three sizes: 30 inches diameter × 60 inches long, 36 inches diameter × 72 inches long, and 36 inches diameter × 84 inches long respectively.

the sliding grating is again opened widely. Air now passes in over the heated baffle plate and out through the grating above; the hot air circulating in the box dries the effects in about 30 minutes, when they can be removed and the lamp extinguished. Formalin (8 oz. of 40 % solution) may be added to the water in the tray if required, but for lice this is unnecessary.

Horse-drawn Steam Sterilizers of various patterns are extensively employed. The Thresh Disinfector Company (4 Central Buildings, Westminster, London, S.W.) has supplied large numbers to the British, Colonial and American troops. These machines (Pls. X, XI, Figs. 3, 5) may therefore serve in a general way as types of such disinfectors except for the special feature that the jacket contains brine.

Although the details of their structure and management will have to be mastered by those intending to use them, it will suffice here to mention the main principles of the construction. The sterilizer chamber is horizontal and double walled, *a salt solution in the jacket*[1] is brought to boiling point (ca. 220° F. = ca. 105° C.) and the steam evolved in the jacket, at a temperature of about 215° F., enters the chamber through a flue at the back; the steam operates at atmospheric pressure or under slight pressure, and expels the air from the chamber. After an exposure lasting usually half an hour, the steam is turned into the shaft and air is admitted to the chamber by opening a valve beneath the chamber door. The air traverses a bent pipe surrounded by boiling brine, being thereby heated before it enters the chamber. A small cistern, on the left outer side of the chamber and connected with the water supply, automatically renews the water in the jacket as the brine grows more concentrated through giving off steam. Calcium chloride was formerly used for the brine, but it caused difficulties by clogging the pipes and it has since been replaced by another salt. The cleaning of the boiler is a matter of some difficulty in all constructions of this kind.

The following are amended instructions issued by the War Office concerning the use of Thresh Patent Current Steam Disinfectors (Furnace-heated), which the writer has slightly condensed, omitting the instructions for cleaning the machine (from *Notes for Sanit. Officers*, B.E.F., France, 1917, p. 44, W.O. publication, 1918).

[1] The term "jaeket," applied to this and other forms of steam disinfeetors herein deseribed, refers to the interspaee between the inner and outer walls of the ehamber. These walls, either oval or round in eross seetion, are riveted at the ends to a ring, thus forming a closed spaee that is filled with steam whieh heats the inner ehamber.

A. Before introducing articles to be disinfected see (*a*) that water flows properly to feed cistern, (*b*) that steam enters chamber freely when turned on, (*c*) that door to air inlet is closed.

B. (*a*) Pack articles lightly in cage to enable steam to circulate. (*b*) Do not let them touch sides of chamber. (*c*) Suspend articles on hooks when liable to crease if folded. (*d*) Load not to exceed 30 blankets or 20 kits.

C. (*a*) Introduce cage. (*b*) Close door. (*c*) Turn steam into chamber and let it pass through 30 minutes, counting from the time 212° F. is attained.

D. Regulate fire to maintain good current of steam. Over-firing creates slight steam pressure causing liquid in supply cistern to rise, in which case turn off steam 1–2 minutes until fire is damped down.

E. At end of 30 minutes turn off steam and open air inlet to allow drying to proceed. Light articles taken out in 10 minutes and shaken will be dry; heavier articles require 30 minutes' drying before removal and free exposure to air until cool.

F. Avoid anything getting into steam and air inlets of chamber.

G. Disinfection by hot air in the chamber is carried out like the drying process except that the heating lasts 2–3 hours (leather, furs, etc.).

Peacock (*MS. Report*, W.O., 1918) states that he has found it better to lengthen the chimney to a height of 8 feet in the horse-drawn type of Thresh machine as this increases the draught. He has heard complaints regarding this machine but attributes them merely to unskilled handling.

Thresh Disinfector mounted on Foden Steam Lorry (Pl. XI, Fig. 6). This form has the advantage of greater mobility than the foregoing. The lorry carries two chambers. Heating takes place rapidly when the lorry arrives at its destination because the steam from the engine that runs the lorry is then diverted into the chambers. The latter can be used together or singly. The temperature attained is somewhat over 100° C., the steam pressure not exceeding 5 lbs.

The War Office instructions (*loc. cit.*) caution especially against mixing steam and air and direct that the specified exposure period shall not be shortened, reckoning this period from the moment that pressure is reached or steam attains the requisite temperature and issues at the outlet. This is stated to be specially necessary with the Foden-Thresh Machines where "in addition to the pressure gauges registering 5 lbs. pressure, the outlet valve ('F' on instructions) should be partially open and a continuous current of steam issuing therefrom." Note the pressure gauge and compare with the instructions. Peacock (*loc. cit.*) states that the whole operation lasts 45 or 60 minutes including 10 minutes allowed for drying.

Thresh Fixed type of Disinfectors provided with one door, but preferably with two (Pl. X, Fig. 4 and Text-fig. 23), are suited for use in hospitals and may be either furnace heated (as illustrated) or steam heated. As

in the preceding two forms, the articles to be disinfected are contained in the usual kind of cradle that slides in and out; in the larger fixed installations such cradles run out on rails. The two doors open respectively into two rooms that are separated by a wall into which the sterilizer is built (see Text-fig. 23). The infected articles are introduced on one side and after disinfection are removed to the "clean" side; this being the

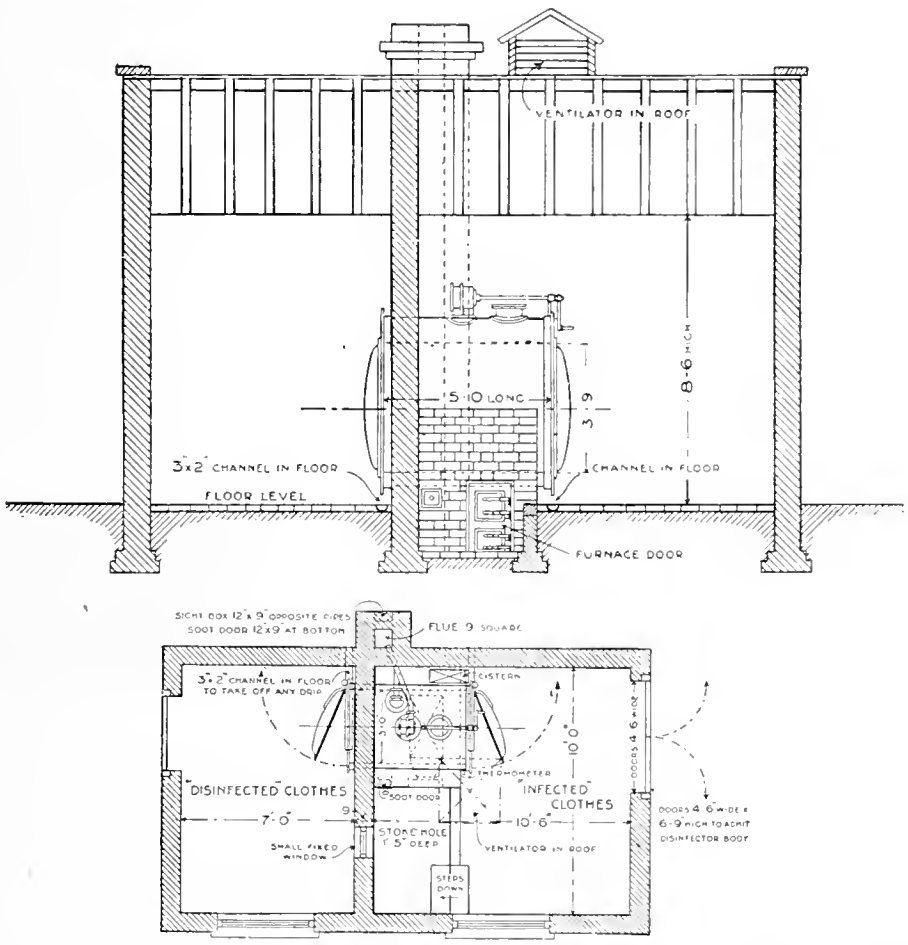


Fig. 23. Thresh Disinfector, furnace-heated type. Permanent installation. Vertical section and plan, showing double door machine 5 ft. long. The doors open respectively into apartments for the reception of infected and the discharge of disinfected clothes.

usual method employed everywhere since steam disinfectors of various kinds were first introduced into well-planned institutions.

The Washington-Lyon High-pressure Disinfectors (Barford & Perkins, Ltd, Peterborough) are also extensively employed, various forms, either fixed or portable, being in use, as with the Thresh. Like these, they have a steam-tight door to the jacketed chamber. Steam at 30 lbs. pressure is first

allowed to enter the jacket, thereby warming the chamber and preventing undue condensation taking place inside; the air of the chamber is partly extracted by a steam jet and live steam at 20 lbs. pressure is allowed to enter it for 15 minutes. The steam is not allowed to escape, but a partial vacuum is again produced in the chamber and hot air, passing through a heated copper coil, combined with the heat from the jacket, dries the contents in about 15 minutes. As already indicated, the temperature of

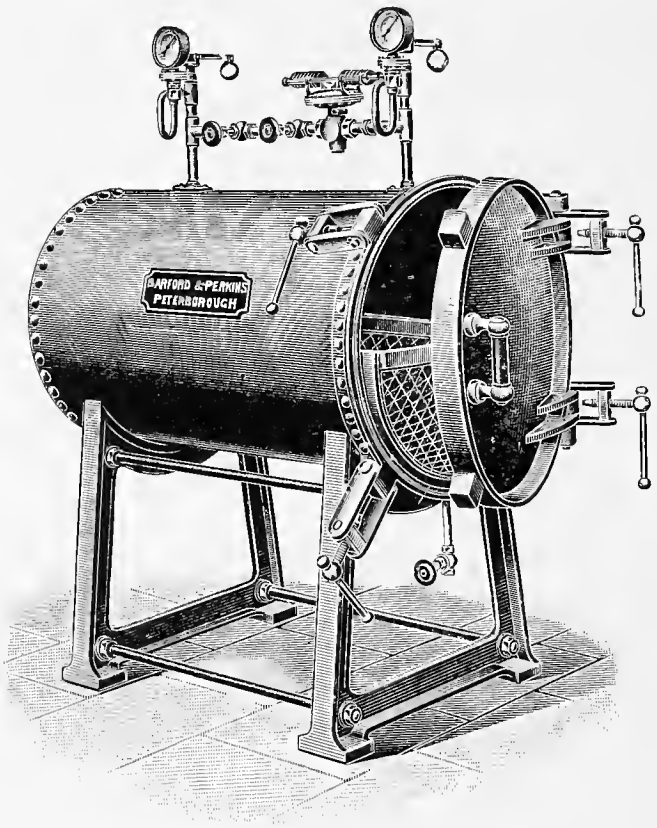
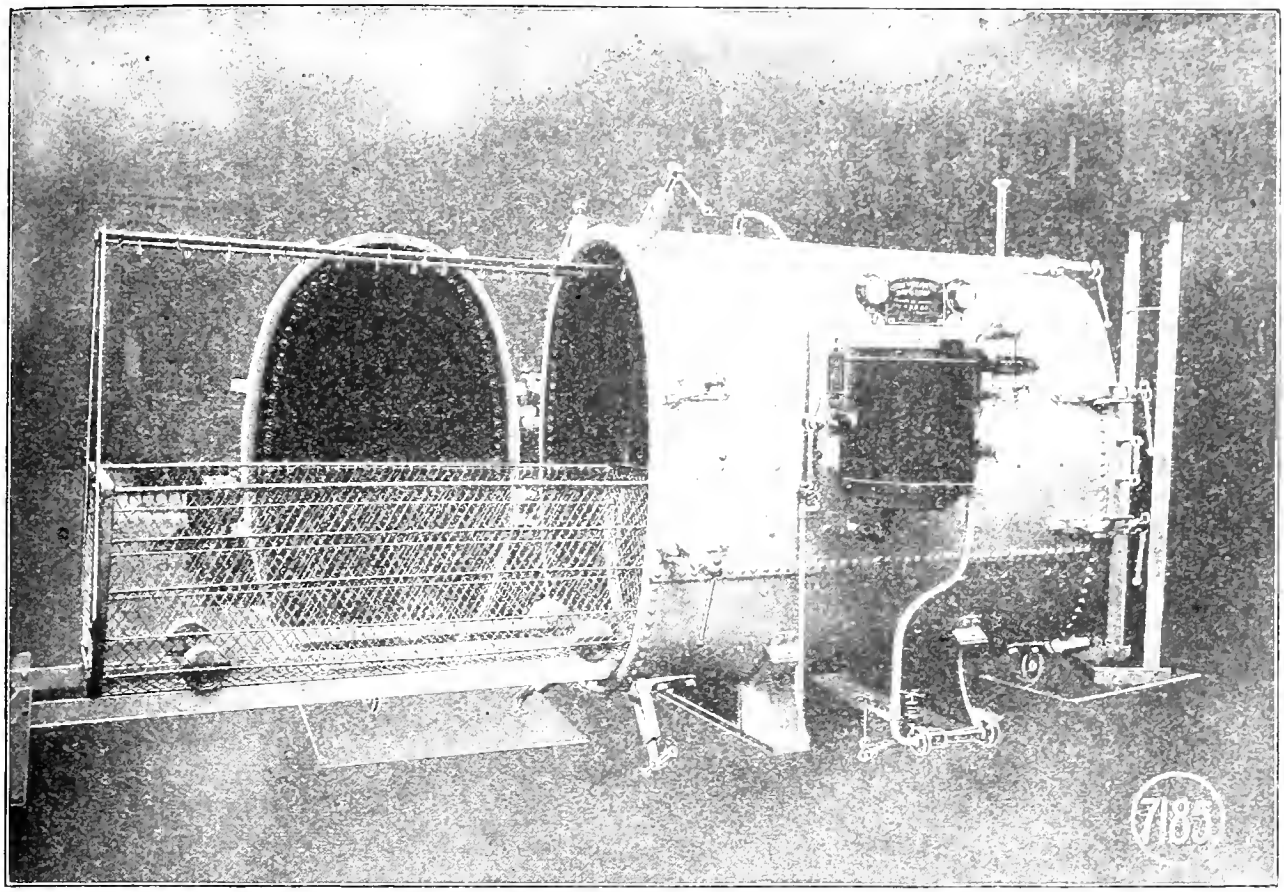
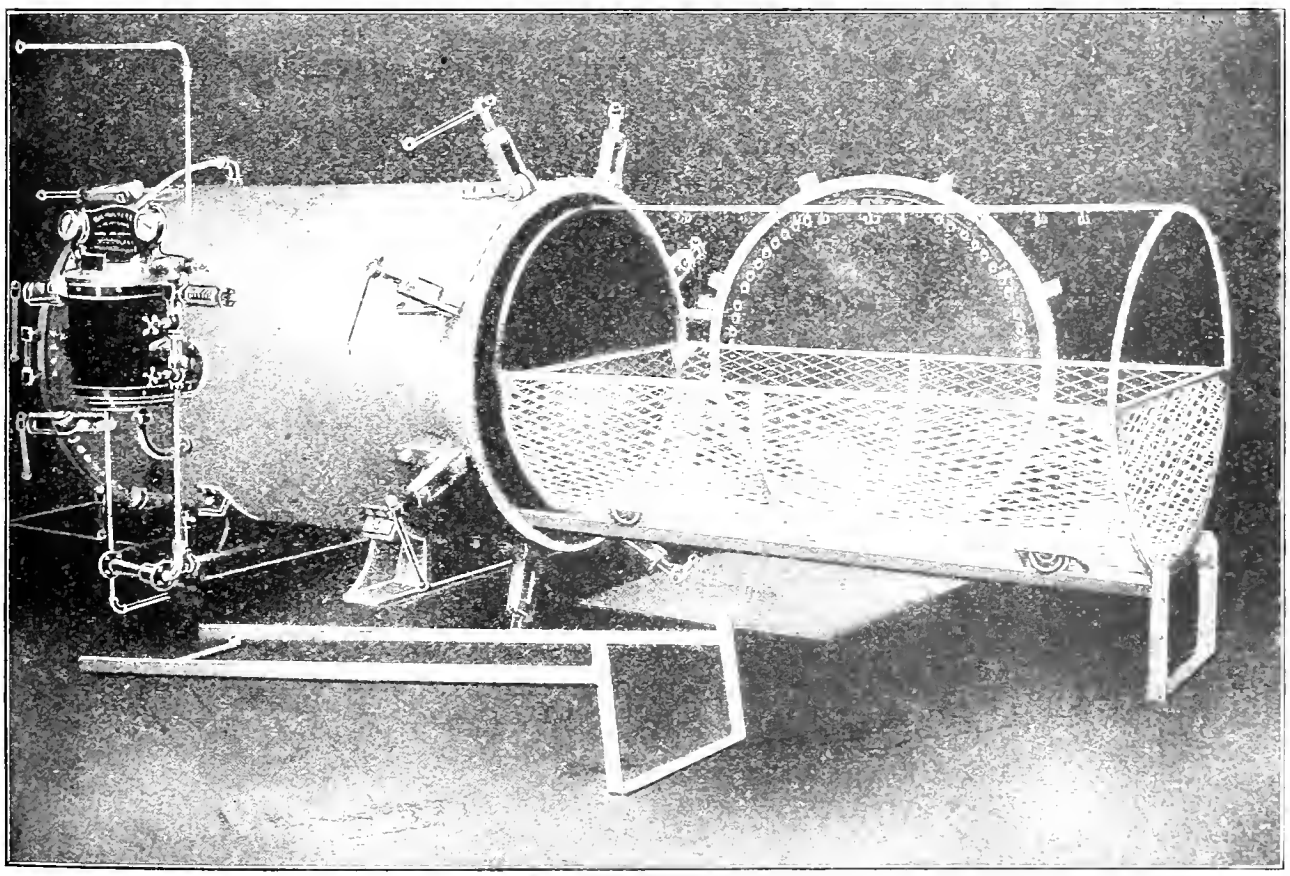


Fig. 24. Washington-Lyon Steam Disinfector. Size of chamber 2 × 4 ft. Will admit a single mattress rolled up. This is "Model 13" as supplied to the War Office and referred to in table on p. 475. It is also made with a door at each end, or, when required, placed on a carriage.

the steam in the jacket is higher than that within the chamber. The apparatus can be arranged to work as a current steam disinfector with saturated steam, at or slightly above atmospheric pressure, the pressure ranging from 1 to 20 lbs.; it can be used for hot-air disinfestation by heating the jacket only, steam not being admitted to the chamber. The steam may be derived from any suitable boiler (Pl. XI, Fig. 7 and Text-fig. 24).



A Fig. 8. Alliott and Paton Patent High-pressure Steam Disinfector. Oval type "L.O." Models "M.O.," "L.O." and "W.L.O." have a cubic capacity of 60 feet, 120 feet, and 170 feet respectively, the height, breadth and length of the corresponding inner chambers being 4.2 × 2.7 × 7 feet; 6 × 3.7 × 7 feet; and 6 × 5 × 7 feet.



B Fig. 9. Alliott and Paton Steam Disinfector. Circular type, made in various sizes ranging from 10 to 138 cubic feet. In the "F.C." model here illustrated, the inner chamber measures 5 × 7 feet, the capacity being 138 cubic feet.

The portable forms are provided with a boiler and furnace, and the door is hinged on one side, the whole being mounted on a 2 or 4-wheeled vehicle. The Model "2 *D*" (see table, p. 475), as supplied to the War Office, is generally similar to the machine illustrated in Pl. XI, Fig. 7, but measures 39 in. diam. × 84 in. long. This form is also made with a single door at one end and mounted on a carriage, preferably 4-wheeled if for use in hilly country.

Alliott and Paton's Patent High-pressure Steam Disinfectors (Manlove, Alliott and Co., Ltd, Engineers, Nottingham, London and Manchester) are made in a large variety of forms suited to different requirements. They employ "dry saturated steam" at 260° F. The makers formerly manufactured the Washington-Lyon but claim to have improved it considerably. Steam enters the jacket at 30 lbs. pressure. A partial vacuum

Fig. 25. Alliott and Paton Horse-drawn Steam Disinfector. The type M.P. here figured has a chamber of 60 cub. ft. capacity and corresponds to L.O. stationary type.

can be produced in the chamber which may be used either for circulating steam or as a hot-air oven. The various types are either circular, oval, or square in cross section. A few of the fixed and portable types are shown in the accompanying illustrations, types "M.O.," "L.O." and "M.P." being such as have been supplied to the War Office (Pl. XII, Figs. 8, 9, Text-fig. 25).

A small "L.C.C." type of "*Vermin Destroyer*" is also made by this firm, being designed for the treatment of verminous clothes in schools. It consists (Pl. XIII, Fig. 10) of a vertical, double-walled, cylindrical, galvanized steel vessel covered outside with asbestos. The vessel is closed by a steam-tight hinged lid with balance weight, the lid bearing hooks interiorly for suspending effects. Water, about 1 foot in depth, is filled into the outer receptacle or boiler (between the double walls) and is brought up to boiling-point by a gas ring beneath or is heated by steam

from any available source. The current steam at atmospheric pressure (controlled by a stand pipe) raises the temperature of the inner chamber to 100° C. Steam may be allowed to enter the inner chamber or not, as required, by means of a three-way cock, the steam escaping into a flue. The apparatus is stated to heat up to 100° C. in 10 minutes.

The "Ibis" Steam jacketed Disinfector (Isaac Braithwaite and Son, Ltd, Engineers, Kendal and London) conforms in general plan to those previously mentioned and is loaded, etc. in a similar manner. The chamber is first heated to 57–60°C. (135–140° F.) by means of steam at 10 lbs. pressure admitted to the jacket; a partial vacuum (15–20 inches) is then produced in the chamber and steam is afterwards allowed to enter at 7½ lbs. pressure. The exposure lasts about 20 minutes, the temperature attained being 107–110° C. (225–230° F.). Steam is then cut off from the chamber and the drying process commences, a current of hot air being admitted into the chamber below and traversing its interior (Pl. XIII, Fig. 11).

In all machines in which a cradle is employed for holding the effects to be treated, there is a general tendency for the articles to become more tightly packed when they are steamed. Peacock (*loc. cit.*), who notes this in connection with the horse-drawn Thresh machine, states that he sought to counteract the tendency by putting an old perforated iron bucket in the bottom of the cradle, above the steam baffle in the centre of the floor, or by placing two-inch wooden battens lengthwise across the top of the cradle.

The Number of Articles with which a Disinfector should be charged, Working Capacity, etc.

It has already been stated that disinfestation, either by hot air or steam, may fail utterly if the chamber is overcharged, it being essential that the effects should be packed in loosely or preferably hung up with interspaces between them thus permitting the hot air to drive out the cold or the steam to drive out the air, otherwise the process has to be unduly prolonged. It is especially important in the practice of military disinfestation to determine what is the *standard load* for a particular disinfector so that the operator can foretell within narrow limits how long it will take to treat the effects adequately at a given temperature allowing for variations outside. Punctuality and measure in all things are of great moment in military affairs.

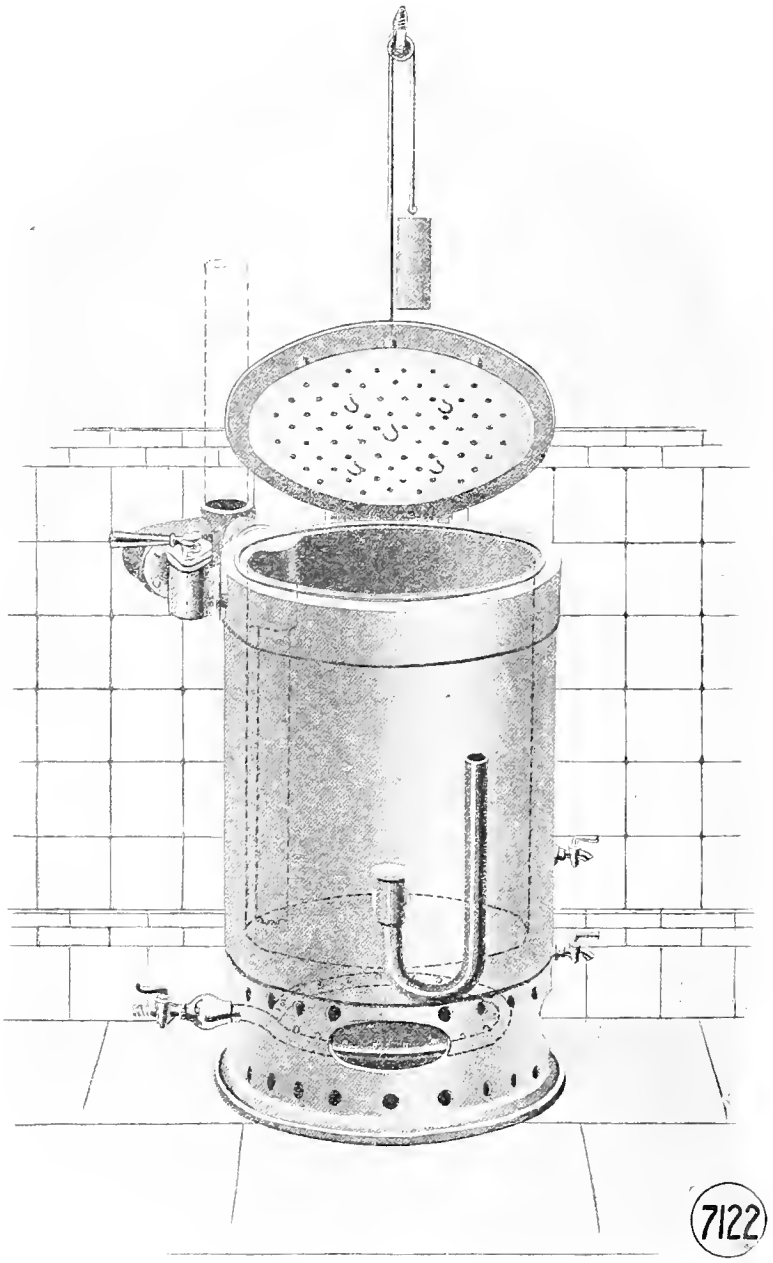


Fig. 10. Alliott and Paton "L.C.C." Vermin Destroyer. Designed chiefly for small requirements (schools, etc.) and using steam at atmospheric pressure.

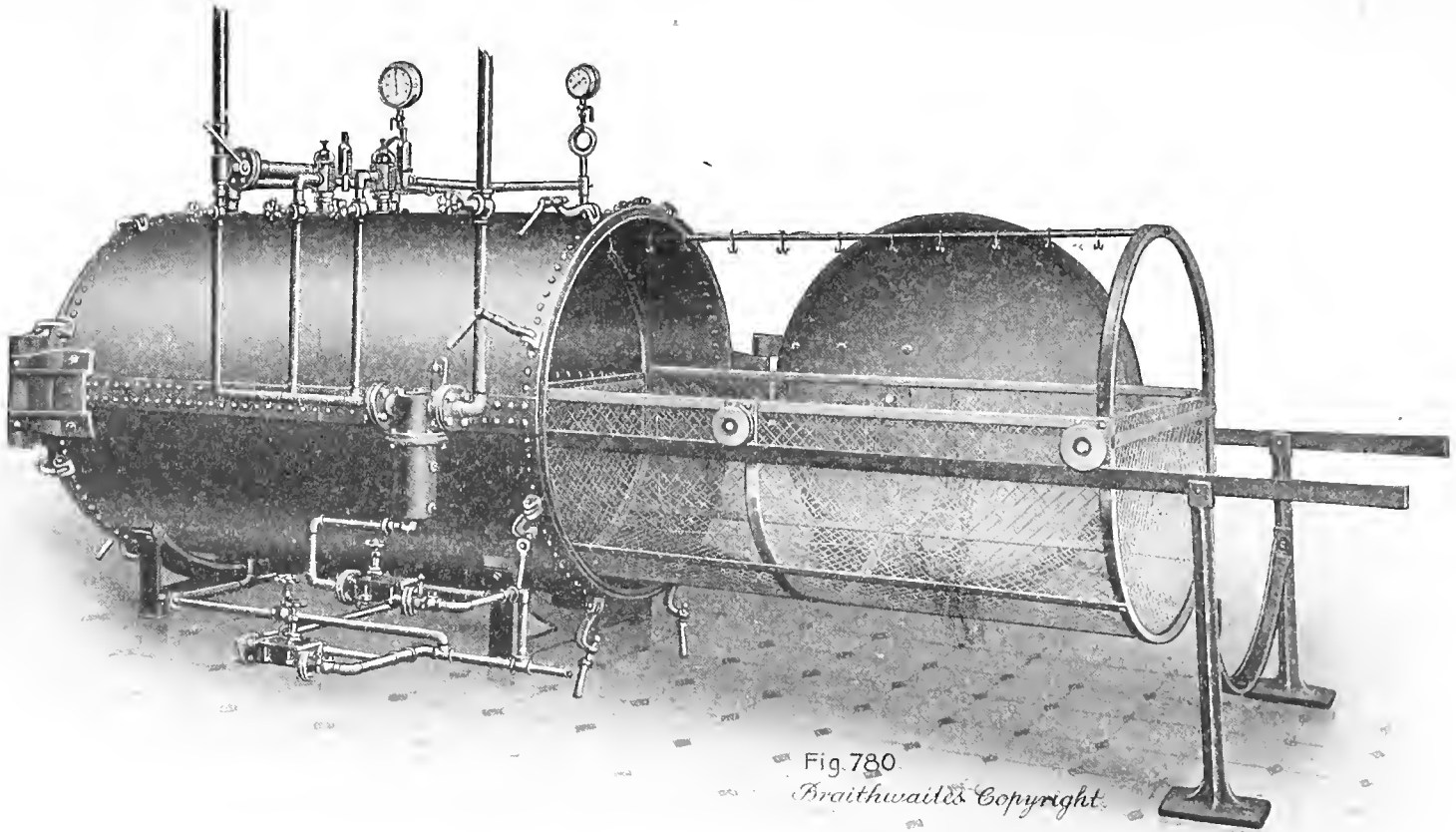


Fig. 11. The "Ibis" Steam Disinfector. For description see text.

Particulars Regarding the Working Capacity, etc., of different Steam Disinfectors.

Extracted, with slight alterations, from *Notes for Sanitary Officers*, B.E.F., France, 1917 (W.O., 1918), p. 42.

	Thresh portable	Thresh fixed	Thresh on Foden-Lorry	Lyon portable, M.O.[1]	Lyon fixed M.O.[1]	Lyon fixed L.O.[1]	Equifex[3]	Lyon No. 2D.[2]	Lyon No. 13[2]	Newman steam and formalin	Portable steam disinfector	Remarks
Capacity in cubic feet	35	50	60 each chamber	60	60	112	112	54	12	32	11	
Steam pressure (atmospheric or lbs)	atmos.	5 lbs	5 lbs	30 lbs	30 lbs	30 lbs	15 lbs	15 lbs	15 lbs	atmos.	atmos.	Pressure in jacket
Temperature ° F. attained (approx.)	212°	218°	218°	259°	259°	259°	239°	239°	239°	176–194°	212°	
Fuel required to start machine in lbs coal	50	80	110	100	100	100	100	110	84	2 qts oil per charge	25	Fuel consumed depends on quality, stoking and protection afforded
Fuel required per hour, lbs coal	15	28	70	40	40	50	30	20	10	—	10	Ditto
No. of blankets per load	30	40	60 each chamber	60	60	130	130	60	10	10	8	This is the maximum charge consistent with efficiency
No. of Kits (exclusive of greatcoats) per load	20	30	35 each chamber	35	35	60	60	35	8	8	6	Ditto
Time required to load, disinfect, dry, and unload, in minutes	60′	60′	61′	55′	55′	61′	51′	50′	28′	56′	—	Time varies according to nature of articles handled

[1] Alliott and Paton Patent; made by Manlove, Alliott & Co., Ltd.

[2] Made by Barford and Perkins, Ltd.

[3] Now obsolete.

NOTE.—To convert Fahrenheit to Centigrade:

$$C = \frac{5\,(F-32)}{9}.$$

An attempt has therefore been made to state how many articles of a given kind should be introduced into a disinfector, and certain articles have been reckoned as equivalent to others in determining the load. Thus Lelean regards (*a*) a blanket, (*b*) a greatcoat, (*c*) a tunic and trousers, and (*d*) underclothes and puttees as equivalent units in measuring the load. There is, however, an inherent fallacy in such reckoned "equivalents" depending, as I would point out, upon the structure of the disinfector and the possibility of packing the objects introduced to the best advantage in respect to the available space. The equivalents that hold for one machine do not hold for another, therefore it is impossible to lay down any general rule. This accounts for what appear to be discrepancies in the statements made regarding the number of articles with which different disinfectors are capable of dealing. In the one case 1 greatcoat = 1 tunic and trousers, in the other 3 greatcoats = 5 tunics and trousers, or again the ratio of blankets to kits (exclusive of greatcoats) is variously given as 2 : 1, 3 : 2, or 4 : 3, etc. Again, the number and character of the effects comprised in a soldier's kit necessarily vary according to season and other circumstances[1].

The correct load for a disinfector is that load which can be adequately treated effectively at a minimum of time, cost and labour and which gives the maximum turnover at the end of a day's work. The correct load can only be determined by an operator as the result of experience. The facts previously stated should be kept in mind when considering the particulars detailed in the following tables regarding the working capacity, etc. of different disinfectors employed in the present war.

Further particulars regarding the working capacity of different Disinfectors.

Lelean (1917, p. 202) defines a soldier's kit as consisting (for purposes of disinfection) of a greatcoat, tunic and trousers, underclothes and puttees, and 2 blankets; these articles collectively being reckoned as equivalent to 5 blankets. Assuming that it takes 45 minutes to load, disinfect, and unload the effects, he tabulates his calculations as follows:

Steam Disinfection.

	Kits including greatcoats per hour	Blankets		Number of disinfectors needed per Division
		per charge	per hour	
Serbian barrels (60 gallons capacity) ...	2	7	10*	80
Field sterilizing box	4	12	20*	40
Thresh (small portable type)	10	38	50	60
Train (2 trucks, each 18 ft. long) ...	150	450	600	1

* Proportion increased by saving 5 minutes in loading and unloading the disinfector.

[1] Uhlenhuth (1915, p. 533) states that he had to deal with Russian prisoners wearing no less than 3 shirts, 2 pairs of drawers and 3 pairs of socks.

From praetieal experience in Egypt, Lelean (1917, p. 204) gives the following working time-table and method of proeedure in disinfecting the kits of 200 men per day, employing 80 Serbian barrels:

Charges.

Underclothes and puttees	Tunics and trousers	Great-coats	Blankets	Serbian barrel starts	
80	—	—	—	8.0 a.m.	
80	—	—	—	8.40 a.m.	
40	40	—	—	9.20 a.m.	
200	80	—	—	10.0 a.m.	
	80	—	—	10.40 a.m.	
	200	80	—	11.20 a.m	
		80	—	12 m.	
		40	40	12.40 p.m.	
		200	80	1.20 p.m.	all clothing sterilized
			80	2.0 p.m.	
			80	2.40 p.m.	one blanket per man done
			80	3.20 p.m.	
			40	4 p.m. to	all clothing and one blanket
			400	4.40 p.m.	per man should be dry

Peaeoek (*MS. Report,* W.O. 1. 1918) states that if all the men's complete kits (v. infra) are ready for treatment, those belonging to 1000 men can be dealt with at the following rates by different proeedures, the cost of labour not being included:

Steam, Hot air and SO_2 disinfestation compared.

Type of disinfector	No. of kits (including greatcoats)	Coal consumed	Cost per kit
Disinfecting train (2 trucks)	250 per 2 hrs	?	?
Steam hut	50 per hr	10 cwt	$\frac{1}{4}d.$
Hot-air hut	90 per 2 hrs	10 cwt	$\frac{1}{4}d.$
Thresh, Foden-Lorry ...	24 per hr	$1\frac{1}{2}$ tons	$\frac{3}{4}d.$
Thresh, horse drawn ...	12 per hr	$1\frac{1}{2}$ tons	$\frac{3}{4}d.$
SO_2 hut*, 2700 cu. ft. ...	120 per day	300 lbs sulphur, $8\frac{1}{2}$ gallons of petrol	$1\frac{1}{4}d.$

* The figures relating to the SO_2 hut are only included here for comparison in respect to working capacity and cost, the figures being tabulated accordingly. The cost of sulphur has since increased.

The following are stated to constitute equivalent loads for a Thresh Foden-Lorry ehamber by Peaeoek (*loc. cit.*): 40 blankets; 150 shirts; 200 sets of vests and drawers; 600 pairs of soeks; 35 sets of tunies, trousers and eardigans; 12 eomplete kits consisting of tunie, trousers, cardigan, shirt, vest, pants, socks, towel and greateoat.

Hunter (MS. cit. p. 463) states that railway van steam disinfectors are greatly superior to anything else for the disinfection of troops and ordnance clothing when troops are near to railway lines. The working capacity of two vans is 500 complete kits per 2 hours; they can deal readily with 2000 complete kits during a working day of 8 hours at a reckoned cost of $\frac{1}{2}d.$ per kit, and this turnover is compared with that of a Thresh machine which can only accomplish the same amount of work in 55 days at a cost of $4\frac{1}{2}d.$ per kit. As equivalent loads per van are given, (*a*) 500 blankets, (*b*) 300 blankets and 150 full kits, (*c*) 500–600 greatcoats, a van can deal (when loaded twice in succession) with all the effects of 200–250 men, namely the full kit, greatcoat and 2 blankets per man. It is estimated that the turnover of two vans amounted to 50,000–60,000 disinfections per month when dealing with the effects of troops and native labourers. Whilst in use the locomotive consumes a $\frac{1}{2}$ ton of coal per day.

Some striking figures are furnished to show the working capacity of two vans on several occasions: They disinfected 7850 kits in 4 days; 10,000 in 10 days (3800 in one day alone); 16,000 in 12 days; 18,000 in 9 days, and 10,000 in 4 days. These figures afford sufficient evidence of the value of the method in dealing with the effects of large bodies of men.

Effects of Disinfection or Disinfestation on Clothing, etc.

I. Steam.

Unsuited for treatment by steam are leather, furs, india-rubber, books, papers, MSS, all articles containing glue or wax or coated with varnish. It should be remembered that stains due to blood and excreta are fixed by steam heating or boiling, they should therefore be washed prior to being treated. Some colours run in fabrics that become wetted by water of condensation. Leather shrinks and grows brittle, furs are ruined.

Suited for such treatment are textile fabrics dyed with fast colours, blankets and bedding. Clothing is liable to *shrinkage* and becomes badly creased if compressed; it should be so nearly dry on removal from the disinfector that it dries completely on being shaken a couple of times in the open air.

II. Hot-air.

Unsuited for treatment with hot air are articles containing wax, india-rubber (if the temperature is too high), and effects stained in the manner referred to under Steam. Wet leather.

Suited for such treatment are all the other articles enumerated under Steam.

Effects of dry heat at various temperatures. The moderate degree of dry heat that is required for the destruction of lice and nits in clothing, blankets, leather, furs, etc., is insufficient to injure them. We have seen that an exposure to hot air at 60° C. for half an hour amply suffices to kill lice in all stages in practice.

Hot air at higher temperatures exerts an injurious effect on *woollens*, thus 104° C. acting for 4 hours whilst but slightly yellowing white flannel, does not affect its tensile strength, but if exposed to 127° C. for half an hour flannel yellows and becomes brittle[1]. At high temperatures, hot air is liable to over-dry fabrics so that they become brittle, but if the heat is moderate this effect can be overcome by letting them reabsorb their usual amount of hygroscopic water from the atmosphere, this being accomplished in a short time by hanging them up freely exposed to the air. *Leather* will shrink and grow hard unless dried before exposure to hot air, it is unaffected by exposure to 60° C. for 1 hour (Uhlenhuth and Olbrich, 1915, p. 776)[2]. According to Kisskalt and Friedmann (1915, p. 398) *furs* are not injured by exposure to 80° C. for 30 minutes but they are damaged by repeated exposure to this temperature or by 78° C. acting for $2\frac{1}{2}$ hours. These authors recommend the use of electric fans in the heating chamber for rendering the temperature therein uniform when treating furs by hot air. Friedmann (1916, p. 321) states that sheep fur withstands dry heat much better than other furs. Seligmann and Sokolowsky (1915, p. 963) are wrong in asserting that temperatures of 120–150° C. do not injure furs and leather.

Relative advantages of Dry and Moist Heat.

From the point of view of louse destruction alone, hot air has many advantages over moist heat, in that it can be applied to a greater variety of objects without injuring them, that a more moderate degree of heat can be applied at a smaller cost of fuel and apparatus, that it causes no shrinkage of fabrics and does not cause colours to run, that it does not remove the natural grease from woollens and render them hard to the touch, that it can be applied without injury to fur and leather (at 60° C.),

[1] Notter and Firth (1908), *Theory and Practice of Hygiene*, London, Churchill, pp. 741 et seq.

[2] Konrich (1912, zur Desinfektion von Lederwaren und Büchern durch heisse Luft, *Zeitschr. f. Hyg.* LXXI. 296–306) exposed books and leather equipments (military) to hot air at 80° C. for 24 hours, he claims without injury. I suspect that the leather deteriorated.

that it does not tarnish metal (buttons, etc.) on soiled clothing, that the clothing is always warm and dry when removed from the chamber and ready for immediate use[1].

Disinfestation by hot air should not take longer than with steam when the disinfestor works efficiently. If heated continuously (see Orr's Hut, *Model C*, p. 447), a hot-air hut will perhaps be found in practice to act more rapidly than a steam hut, for the time occupied in the drying process and the manipulation of shaking the effects (on removal after steam disinfestation) must be reckoned to the total time required.

On the other hand steam is greatly superior to hot air as ordinarily employed when it comes to disinfecting effects harbouring *pathogenic bacteria*. Stagnant hot air is inadequate for the purpose unless a high temperature is used, and this injures the articles exposed. Therefore, since steam accomplishes both the destruction of bacteria and lice it has the advantage of fulfilling a double purpose. The choice between dry or moist heat will therefore have to depend upon practical considerations in particular circumstances.

It has been shown of recent years that *current hot air* is much more effective than stagnant hot air as a means of disinfection and there is reason to believe that in certain circumstances it may be used in place of steam. The earlier work of Koch and Wolffhügel (1881, *Arb. a. d. Kaiserl. Gesundheitsamte*, I. 301) demonstrated that *stagnant hot air* at 100° C. kills the vegetative forms of bacteria in 90 minutes, at 110–115° C. spores of moulds are destroyed in 90 minutes, whilst bacterial spores are only killed by an exposure for 3 hours at 140° C. This temperature injures fabrics, and, even after an exposure of 3–4 hours, bulky articles like clothes, bundles and pillows are not penetrated by the heat. This led to the general condemnation of hot air as a means of disinfection. When hot air circulates, however, the results are entirely different. Thus Schumburg (1902, p. 181)[2], experimenting with a coffee-roaster, found that when it was rotated, spore-bearing bacteria enclosed therein in paper packets were mostly killed at 80–100° C. in 1 hour, whereas if they were not rotated whilst maintained at the same temperature, they survived. This doubtless led to Vondran's apparatus being evolved wherein

[1] The following rhyme, painted in large gothic letters along the beam of a German lousing establishment figured in an illustrated journal, although not scientific evidence, may indicate that the Germans prefer to destroy lice by dry heat: "Hölle, wo die Läuse braten, ist der Himmel für Soldaten" (Hell, where lice roast, is Heaven for soldiers).

[2] Schumburg (1902), Ueber die Desinfektionskraft der heissen Luft, *Zeitschr. f. Hyg.* XLI. 167–184.

hot air is forcibly propelled through clothing and effects confined in a chamber (see p. 451).

That heat, dry or moist (steam or boiling water), is superior to any chemical agents for the destruction of lice in clothing is held by Fränkel, Meltzer, Seitz, Engelhardt, Wulker, Galli-Valerio, Legendre, Lelean and others who have had practical experience. In dealing with isolated cases it may, however, be more convenient to use other means.

Recording the Temperature of Disinfectors.

To be certain that the requisite temperature has been attained among effects subjected either to hot-air or steam disinfection various tests may be employed. Unless the objects are loosely hung in the space and a considerable margin of time is allowed, it is impossible, even in the case of current steam, to rely upon timing the exposure from the moment that the steam issues freely from the apertures of the heating chamber. Steam may issue freely without having necessarily penetrated the effects suspended in the chamber, and the same statement applies with regard to hot air.

The most accurate way of determining the temperature is necessarily by thermometers. Contact or electric thermometers have been in use for many years for the purpose of signalling to the person in charge of the disinfector the moment when a desired temperature has been attained in that part of the disinfector in which the instrument has been placed.

A crude method of determining if the temperature in a steam sterilizer has attained ca. 100° C. and been maintained for a certain time, consists in placing a medium sized potato in the chamber and seeing if it is cooked. In the same way a hen's egg or lice and their nits have been employed to determine if the effects in a disinfestor have attained the desired lethal temperature. Neither of these methods commends itself. A temperature of 100° C. is unnecessarily high for louse destruction and test-lice and nits are totally unsuited for practical purposes.

Bacot (4. VIII. 1917, p. 151) has suggested the use of vessels containing paraffin of a known melting point as a means of registering whether or no a lethal temperature (60° C.) has been attained in the chamber. Jacobs (1918, p. 238) also advocates the use of paraffin sealed in tubes containing a bead which gravitates when the paraffin melts. Emrys-Roberts (4. V. 1918, p. 509) describes and figures a "wax thermometer." Such methods are very unreliable and need not detain us.

A very simple, accurate, cheap and practical method of determining if the lethal temperature (instead of using maximum thermometers)

has been attained is one that has been in use for some time in Boulogne. I am indebted to Captain C. G. L. Wolf, R.A.M.C., for information concerning the method. The principle consists in using pure chemical substances whose melting points we know are constant. Mallic acid was employed in Boulogne. The main thing is that the substance should be cheap, easily procurable, and in no way dangerous. The substance is mixed with a minute quantity of any available dry aniline dye which need not be pure. When the substance melts it promptly dissolves the dye. If a colourless substance is mixed with a finely divided dye, the mixture appears almost colourless but almost instantly takes on the colour of the dye when it melts, bright blue, green, red, or otherwise. I would suggest, therefore, where it is desired to record different temperatures, that different substances be used in conjunction with different dyes. The substance mixed with dye is placed in small glass tubes sealed so that they are rounded off at both ends, measuring ca. 5 cm. in length with a calibre of 0·5 cm. or less. The following list of melting points may prove useful, any chemist should be able to amplify it to suit particular requirements.

Melting Points ° C.

100° Mallic acid	63° Cumidin, 1, 2, 4, 5	or Paraiodonaline
82° Glucose	60° Margaric acid	,, Dinitrotoluol, 1, 2, 4
76° Urea	55–56° Azotoluol	,, Dimethylhydrochinon
70° Stearic acid	54° Benzylidine aniline	,, Myristic acid

Faulty Methods and common sources of failure.

As *common* sources of failure in hot-air and steam disinfestation in the army may be reckoned the following factors:

1. That *individual men and their effects escape disinfestation* and consequently serve as carriers and disseminators of lice to their cleaned companions.

2. That *every* verminous article belonging to *every* man has not been treated, with the result that some men become reinfested through wearing their own (or borrowed) untreated clothing perchance carried in the kitbag. Cardigans are likely to escape disinfestation and there may be a lack of clean change of garment for every man; underclothes but not the outer garments may have been treated, etc. The bed outfit, great-coat, even the cap and kitbag may harbour lice.

3. That the *men's bodies* have continued to harbour lice.

4. That the *personnel handling infested effects* do not follow the rule of wearing different outer garments (over-alls and hoods) when dealing

with infested and disinfested articles respectively. Disregard of this simple rule may lead and has led to failure in the presence of the best installations. The personnel should be provided with washing facilities to be employed between shifts. Infested men handling disinfested articles may readily reinfest them.

5. That *clean articles have been stored, perhaps but temporarily, where infested effects have been kept.* Clean and infested articles should be rigidly kept apart and separately stored. An annex of the simplest kind placed on either side of a disinfestor will answer the purpose.

6. That *carts or transport waggons* used for the conveyance of infested articles are employed to transport clean effects. The vehicles should be first disinfested by means of a steam jet or by washing them down with insecticide solution.

7. That *a fundamental principle is often disregarded* in disinfestation establishments, in that there is no separation of a *clean side* from an *infested side*, the clean articles becoming reinfested in various ways. Wherever possible the disinfestation plant should be arranged to meet this requirement (see Fig. 26, p. 561). A separate wall or fence may answer the purpose in the open, disinfested articles being hoisted over it.

8. That disinfestation has been improperly carried out owing to *undue haste*, *carelessness* or *ignorance*.

It is a common complaint that *steam* may be insufficient in destroying lice. Two such instances came under my notice over 20 years ago, the explanation in both cases being of course perfectly simple, i.e. the steam was not given time to penetrate the clothing. The statement by Busson (1915, p. 674) that steam was found ineffective in killing nits and that hot ironing had to be resorted to, affords but a similar instance of faulty method.

Owing to the fact that nits remain attached to disinfested clothing the ignorant frequently blame the disinfestation process as inefficient, not knowing that dead nits and empty egg-shells are only removable with difficulty by hand. They have no more significance than the occasional presence of dead lice that have not been removed mechanically from clothing.

As an amusing example of faulty methods erring on the heroic side, may be taken that recorded by Eckert (1915, pp. 918 et seq.) wherein the author describes a process for the destruction of vermin on a large scale in a sealed room by burning CS_2 to which flowers of Sulphur and Papricka were added. The mixture was placed in pans and ignited. Lice and nits were killed by an exposure of 2 hours. He treated the clothing

of 8000 men within 4 days by this method, and used it for a period of 7 months. At the end of his communication he states incidentally that the temperature inside the room attained 100° C. In short the heat produced more than sufficed to kill the vermin, a fact which did not apparently occur to Eckert.

2. PEDICULICIDES AND REMEDIES FOR LICE.

General considerations.

The mode of action of Pediculicides.

Before considering the various remedies that are employed against lice, it is expedient to dwell briefly upon their mode of action, because it is evident that this must vary according to the nature of the remedy.

Physical effects alone doubtless explain the pediculicidal action of indifferent fluids, oils and fats, since these will occlude the spiracles in the active stages and the opercular orifices of the nits, thus checking the insect's respiratory processes (v. infra). Unless plentifully applied, the lethal action of such substances will necessarily be but partial and it is therefore usual to employ them as vehicles for insecticides. Mercurial ointment may be taken as the type of a remedy which exerts a combined effect, physical through the fat and chemical through the mercury which is stated to exert its insecticidal action through being volatilized. The speed with which an insecticide acts depends upon its penetrating power through the chitin and the external orifices in the insect's exoskeleton coupled with its particular chemical affinity for the animal's tissues.

Direct toxic effects are induced by various mineral or organic vapours, operating either in solutions in which the insects are immersed or pervading the atmosphere in which they are confined. These vapours act most rapidly when concentrated and when the temperature is moderately high as experiments have shown. Labbé and Wahl (1915, pp. 872–888), who have made an experimental study of the effects of toxic vapours on lice, have reached conclusions similar to mine. They distinguish two stages of intoxication wherein the insect exhibits: (1) agitation, torpidity, spasms, etc. followed by (2) apparent death from which they may recover, and, if the exposure continues, (3) death. Insecticides act in various ways, relatively speaking, some immobilize quickly and have slow killing power, others immobilize slightly but kill more quickly, whilst others again are intermediate in their effects.

The insecticides tested by Labbé and Wahl were more or less volatile and diffusible. The reader is referred to the original for further details, but it may be stated here that the whole subject requires scientific investigation.

Knaffl-Lenz (1915, p. 708) believes that acid vapours are the most potent because they neutralize the alkaline body-fluids of the insect and prevent the giving off of CO_2 as observed in poisoning by acids; such vapours are best used in practice because the insects do not recover from their effects. Neutral and alkaline vapours, on the other hand, do not enter into chemical combination in the louse's body; they are dissolved and if their action is not prolonged their effects are transitory. The acid vapours commonly used are sulphur dioxide and acetic acid, and formic acid is suggested as worthy of trial.

Many experiments conducted in vitro, are found worthless when the results are applied in practice. This may be due to several causes. Many authors, as some of the following protocols show, fail to state the conditions under which they conducted their experiments, two matters of fundamental importance, namely the vapour concentration and the temperature frequently receiving no mention. The *essential oils* mostly stand condemned on the grounds: (*a*) that their effects are transitory because they evaporate too rapidly; (*b*) that in practice as a rule they are too expensive; (*c*) their smell is frequently objected to and some persons exhibit idiosyncrasies with regard to their effects; (*d*) some of them, whilst they rapidly stupefy the active stages, fail to exert an appreciable effect on the nits. According to Sikora (VIII. 1915, p. 529) a small amount of the vapour of several essential oils inhibits the development of nits in vitro and the author regards the negative results in killing nits by such vapours as due to the too short exposure. There is however a general consensus of opinion to-day that the vapours of essential oils only suffice in practice to stupefy the insects temporarily without affecting the nits, consequently they are regarded merely as palliatives. From a practical standpoint the exact mode of action of an insecticide is immaterial provided it exerts the effect desired. At this juncture, therefore, we need not dwell further on the subject.

Choice of Insecticides and Mode of Application.

The choice and manner of applying insecticides in practice depend entirely upon the conditions which have to be met, and whether they are to serve merely as palliatives or not. Insecticides or mixtures

containing them may be used alone or in combination with heat, and mechanical methods of removal. They may be applied in a variety of ways, either alone or with other ingredients in the form of powder, solution, emulsion, suspension in fluid or ointment, as a vapour or gas. An insecticidal fluid may be used as a wash, dip or spray, and, like powders, may be confined to sachets whence the toxic vapour escapes into the atmosphere between the clothing and body. In some cases the insecticide should be dispelled before the clothing is worn, in others not, this depending upon the degree of toxicity it possesses for man.

Powders. Numerous powders charged with insecticides have been extensively used and recommended. There are several objections to powders: (1) they are a wasteful method of applying the insecticide, (2) the latter is very unevenly distributed upon the clothing and individual and a great deal too much of it may come in contact with the skin, (3) a powder always tends to gravitate and may accumulate where it is not wanted, (4) the vehicle with which it is mixed may be unsuited for coming in contact with perspiration, (5) a powder, especially when it contains chalk or starch, may soil the clothing.

Sachets have a very limited radius of action and it is doubtful if they give results at all commensurate with the labour and cost they involve.

Sprays necessarily offer an imperfect means of applying insecticides to man and his clothing, but there are circumstances in which they may be useful.

Impregnated clothing. The ideal method of using insecticides upon the person should consist in the impregnation of the clothing therewith; for this purpose the insecticides should not be injurious to the skin, not soil the clothing, not be too volatile, and be removable by washing. This ideal, however, remains to be attained (see p. 500).

The Effects of Greasy Substances and Oil.

In the section on the biology of *Pediculus humanus* reference was made (p. 85) to the remarkable immunity to head-lice observed in certain classes of negroes in the United States, this immunity being attributed to the liberal use of pomades and cosmetics upon the hair of the head. Fiebiger (VII. 1915, p. 645) states that greasy-headed people are free from *capitis*, and Nysten (1858, p. 1140) and Perroncito (1901, p. 597) mention olive oil as a cure for head-lice; the former refers to it as an infallible and simple remedy. Brumpt (1910, p. 550) records from his travels that melted butter is applied to the head by the Somalis,

Abyssinians and Gallas, and if they cannot procure it they shave their heads. Girard (1885, p. 1083) is no doubt correct in attributing the effect of oils and grease on the louse to their asphyxiating the insects by occluding the respiratory apparatus, and some recent authors appear to have reached the same conclusion. Moniez (1889, p. 227) recommends simple olive oil for the destruction of *Ph. pubis*, adding, however, that it does not destroy the nits. Heymann (18. VIII. 1915, p. 311), writing of the unfavourable influence of naphthaline-vaseline on body-lice, thought that the effect might be due solely to the vaseline and that any grease might exert a similar influence, adding that an old treatment for lice on pigs consists in the application of tallow. Weidenheld and Puley (1915, p. 153), moreover, record that Carpathian shepherds keep off body-lice by soaking their clothes in melted butter; they wear such clothes for months unwashed. These authors conclude that the lice either do not lay eggs on greasy surfaces or object to the rancid odour[1]. Hase (XI. 1915, p. 158), whom I have cited on p. 92, states that many soldiers told him that dirty greasy shirts were a safeguard against lice and that some of the men temporarily relieved themselves from the attacks of lice by greasing their bodies.

There are no recorded experiments upon the destruction of lice by oils and fats that possess any value. Kinloch (1915, pp. 1038–1041) states that vaseline has "no effect" and that colza oil has "little effect," whilst Castellani and Jackson (1915, pp. 253–255) assert the contrary, namely, that vaseline kills "at once." In neither case do the authors mention how they made their experiments and in neither case are the statements credible. Lelean (1917, p. 161), who recommends greasing the seams of clothing to kill lice and nits "at once" by asphyxiation, also gives no evidence to prove that lice are killed and not merely temporarily immobilized by the grease.

In the absence of direct experiments, the practical experience summarized in the paragraph preceding the last gives grounds for reflection. It appears reasonable to suppose that oil or grease of any kind possessing a sufficiently low melting point will with time suffice to asphyxiate lice and their nits with which they are brought in contact without the addition of medicaments. This would point to the fatuity of complex recipes for ointments of the kind elaborated by medical men and others but for one reservation, namely the addition of (*a*) medicaments having antiseptic, curative or soothing properties which

[1] Fränkel (1915, p. 313) adds that butyric acid (vapour?) is fatal to lice in an hour and a quarter.

prevent the decomposition of the oil or grease and influence the diseased condition of the skin or (*b*) aromatic principles added merely to render an ointment agreeable.

In view of this statement it would be of practical interest to determine, for instance, in cases of uncomplicated *Phthirus pubis* infestation, if simple ointment liberally applied is not perhaps almost as efficacious as the mercurial ointment so generally employed, having regard to the frequent objections there are to the use of mercury. This remark also applies to the use of similar remedies in simple cases of infestation with head-lice and body-lice.

The asphyxiating effect of oil and grease upon lice is assumed to be due to a film of grease formed over the respiratory orifices of the active stages or the opercular pores of the nit, thus preventing respiration in a manner comparable to what is observed when mosquito larvae and pupae are asphyxiated by a film of petroleum spread on the water which they inhabit. In addition the greasing of the hair may perhaps render it more slippery and difficult for the louse to grasp, or it may to some extent mat the hair and thus impede the formation of the chitin tube in the act of oviposition. *Single* hairs when smeared with olive oil (droplets of oil being excluded) do not impede normal oviposition, as I have found by experiment.

"Repellants."

A great deal has been assumed regarding the supposed repellant effect of various substances on lice, it being repeatedly stated that lice are kept away from a person by their application to the skin or clothing. A survey of the literature, however, affords scarcely any positive information on the subject, most of the evidence being negative.

Positive evidence. Teske (1915, p. 346) states that lice scatter away from oil of anise dropped upon cloth infested with insects. Sergent and Foley (VI. 1915, p. 378) state that oil of eucalyptus repels lice; they placed lice in a dish between two pieces of cloth 4 cm. apart, the one was oiled, the other not; after about three hrs 3 lice were found to have approached the eucalyptus cloth and died, whereas 17 lice were found on the untreated cloth. Jeanneret-Minkine (1915, p. 136) put a ring of glue upon a board placed near a stove; concentrated tobacco infusion was placed in the ring, and two layers of cloth laid upon it with the lice between the cloth layers; the lice fled outward and became stuck in the glue.

Baeot (*MS. Report*, W.O. 20. III. and 13. IV. 1917) liberated liee upon a sheet of paper plaeed on a table in front of a window; a strip of paper 7–10 mm. broad, smeared with the repellant to be tested, was plaeed athwart the path pursued by the liee in walking away from the souree of light. It will be seen that some substanees gave negative and others positive results:

Expt. No.	Substance tested	Result
1	Oxford grease	Of 20 liee all erossed barrier unhesitatingly
2	Vermijelli	„ „ „ „ „
3	Naphthaline 25 % and Oxford grease 75 % ...	Of 20 liee 4–5 crossed barrier, 2 turned back thrice, and 14 walked along barrier to end
4	Crude "Parasitox" ...	Of 21 liee 16 crossed barrier eventually whilst 5 turned back after 2–3 attempts. There was more hesitation than in experiment 3
5	Naphthaline, erude, 90 % and soft soap 10 %	Of 20 liee 17 crossed barrier, with less hesitation than in experiment 4
6	Carbolie acid, erude, 5 % and soft soap	Of 20 liee 11 crossed barrier eventually and 9 turned back. They were baulked by the barrier at a distance of 4–5 mm.

		Crossed barrier unhesitatingly	Hesitatingly	Repelled
7	Crude naphthaline 47½ %, carbolie acid 2½ %, Oxford grease 50 %	3	9	5
8	Naphthaline, erude, 25 %, carbolie acid 2½ %, Oxford grease 72 %	6	5	6
9	Naphthaline, erude, 25 %, Oxford grease 75 %	5	9	3

Negative evidence as to repellants may be eonsidered under four headings:

(1) It has been found that persons may be attaeked under natural eonditions in spite of applying so-ealled repellants to their persons. This oft-repeated experienee led some authors to eondemn repellants as useless in praetiee. It is diffieult to eheek the value of sueh evidenee.

(2) So-ealled repellants plaeed on persons or their elothing, or tested in vitro, do not repel liee under experimental eonditions. Thus Noeht and Halberkann (1915, p. 626) observed no repellant effeet from "various reagents." Wulker (1915, p. 628) found that liee ran toward substanees whieh should have repelled them. Heymann (VIII. 1915, pp. 311–312) saw no evidence of naphthaline, "Globol" and "Lausofan" exerting a repellant effect either in vitro or when smeared upon the skin. Friekhinger (1916, p. 1254) smeared various essential oils, inseet powder, naphthaline, ete. aeross their path or upon the shaved skin of a guinea-pig, and found that the inseets were not repelled thereby.

(3) Experiments have amply demonstrated that hungry lice will bite and suck blood from an individual in spite of his skin being anointed with so-called repellants. Thus Heymann (III. 1915, p. 253) found that hungry *corporis* bit through the skin anointed with various essential oils, but they disliked grease. Kinloch (VI. 1915, p. 1041) found that hungry lice fed through ointment on the skin (he tested sulphur, Peru balsam, storax, oleate of mercury, chrysarobin, staveacre and black hellebore, heavy mineral oil) and states that they prefer a clean arm; merely putting lard on the arm was as effective as any of the foregoing remedies. Heymann (VIII. 1915, pp. 311–312) saw hungry lice bite through tricresol powder, "Anisol," etc. applied to the skin, whilst they ran about for hours when pure naphthaline was dusted thereon; the lice disliked naphthaline-vaseline, but he thought any grease would exert the same effect by making the skin slippery. Widmann (IX. 1915, p. 1336) saw hungry lice bite in spite of cresol, formalin, "Anisol," etc. applied to the skin. Galli-Valerio (1916, p. 37) obtained a like result with "Anisol"; Swellengrebel (1916, p. 26) experimented on lice that were in the act of feeding, by applying various so-called repellants to the skin near them or directly to the insects; the results were negative unless the insects got into the fluid, when some died; he tested essential oils (anise, fennel, turpentine, bergamot, rosemary, orange), "Texan" of Gross, "Anisol" of Fränkel, "Globol" of Nocht and Halberkann, cresol as recommended by Herxheimer and Nathan, "Lausofan" (Bayer and Co.), and naphthaline and iodoform dusted on the insects in powder. A small amount of oil of anise or Anisol killed or stupefied the lice but did not repel; $2\frac{1}{2}$ % carbolic acid drove them off when feeding and killed if it wetted them, mustard oil likewise drove them off but it irritated the skin; neither of these substances could be used in practice as repellants. An aqueous solution of H_2S did not stop their feeding though it might kill them if dropped on them. On the other hand they avoided mercurial ointment (effect of grease alone?).

Prior to having read the papers of the authors above cited, I tested 36 different reagents smeared upon the skin immediately before placing numerous hungry body-lice upon it; the results were negative almost throughout. The lice fed normally and promptly on the skin anointed with oils of citronella, eucalyptus, peppermint, thyme, cedar, sassafras; with linseed oil containing 1 to 25 % naphthaline, camphorated olive oil, tar and olive oil (strong), strong tobacco infusion, terebene, turpentine, glycerine, quassia in 90 % spirit and infusion, nitrobenzene, eugenol, colophane, vermijelli, white precipitate ointment, pyrethrum powder,

and Cooper's dip. Oils of pennyroyal, bay and geranium appear to disturb the insects. Olive oil containing 10 and 25 % oil of cloves had no effect, whereas the lice attempted to feed but failed to do so when the skin was anointed with pure oil of cloves, oil of bergamot and terebene. They became immobilized in 4 minutes in contact with clove oil and died, but after a few hours recovered from the effects of terebene and bergamot.

(4) It is commonly stated for instance that naphthaline sachets must exert a repellant action because persons wearing them remain free from lice. There is no scientific proof of this, for lice may be absent owing to other causes acting singly or combined, all the credit being given to the "repellant" whereas the individual freedom from lice may be due (*a*) entirely to the insecticidal effect of the substance or (*b*) to more care being taken to keep the individuals free from vermin. Some authors, as already stated (vide (1)), deny that they have seen any benefit from "repellants."

Critical Considerations and further Experiments.

The contradictions contained in the statements above cited evidently requiring an explanation, I determined to make some further experiments to discover if there are substances which actually repel lice. The only experiments hitherto recorded which appeared convincing to me are those of Bacot (hitherto unpublished, see p. 489), but in my opinion they are somewhat vitiated by the manner in which they were conducted, the repelling effect of the substance tested being considerably obscured by the counter repellant effect of light upon the insects. Even in the experiments which gave the most positive results many insects shunned the light more than they did the repellant (carbolic acid, naphthaline); the tests therefore give an unfair measure of the potency of the repellants tested.

The other experiments indicating that lice may be repelled by certain substances (see p. 488) are open to the criticism that the authors did not perhaps guard themselves against obvious sources of error:

(1) In Teske's experiment the lice might have scattered anyhow without any repellant being present as I have frequently seen them do.

(2) In Sergent and Foley's experiment the influence of light was perhaps not considered; there is no proof that chance distribution was excluded and that both pieces of cloth were identical in texture.

(3) In Jeanneret-Minkine's experiment the same criticism holds as for that of Teske with the added factor that the lice may also have been repelled by the heat from the stove.

These experiments were therefore repeated under the following conditions at ca. 15° C.:

Exp. I. (Control to that of Teske.) Two glass dishes were placed side by side and a piece of cloth of the same size and fabric was placed in the centre of each dish; 50 hungry lice were transferred to each piece of cloth. About 0·5 c.c. of oil of anise was dropped on one of the pieces of cloth. After 2½ hrs 31 lice had abandoned the anise-cloth and 30 had left the control cloth. The experiment therefore did not prove that anise repelled lice in the slightest degree.

Exp. II. (Control to that of Sergent and Foley.) A piece of cloth was cut in two parts of equal size, the pieces being placed side by side, 4 cm. apart, in a glass dish. 50 lice were placed in a mass between the two pieces of cloth upon one of which was dropped the repellant to be tested.

Oil of Eucalyptus, tested in the light. After ½ hr there were found 3 lice on the eucalyptus cloth, 44 on the clean cloth and 3 scattered in the dish. After 2½ hrs there were 11 lice on the eucalyptus cloth, 15 on the clean cloth and 24 scattered in the dish on the side furthest from the eucalyptus.

Tested in the dark. After 1⅓ hrs there were 16 lice on the eucalyptus cloth, 15 on the clean cloth and 19 scattered in the dish.

The amount of oil used was small (1 drop). At first the result was striking, but later, owing to some oil having evaporated, the effect ceased to be evident as shown in the experiment carried out in the dark. The experiment was now repeated in the dark with

Oil of Anise. Result after 1½ hrs: 3 lice on anise-cloth, 5 on clean cloth, 42 scattered in the dish on the side furthest removed from the anise.

Oil of Cloves. Result after 1½ hrs: 0 lice on clove-cloth, 47 on clean cloth, 3 scattered.

These experiments therefore demonstrate conclusively that the three essential oils tested in small quantity exert a marked repellant effect on lice through their vapour.

Exp. III. (Control to that of Jeanneret-Minkine.) Carried out as described by the author, but omitting the stove and placing the cloths in a glass dish. 50 lice tested. After 2⅙ hrs only 8 of the lice had abandoned the cloth. Therefore there was no evidence of repulsion.

Note. In the section on biology (p. 180) it is stated that there is no evidence of lice possessing an olfactory sense. The foregoing experiments do not establish that the insects possess such a sense for the repulsion may be due to other causes. In this connection may be cited an experiment of R. Crocker's (quoted by Dubreuilh and Beille, 1895, p. 121) wherein 4 students were placed about a table on which a louse was placed. Crocker states that whatever position the louse and men took up, the insect always walked toward the same man. As nothing is stated with regard to the possible effects of light and the colour of the men's clothes upon this choice on the part of the insect I repeated the experiment as follows:

Exp. IV. 100 hungry lice were dropped in the centre of a large piece of brown cardboard on the rough surface of which was drawn a circle. The card was placed on a support about breast high in a room moderately lit by an electric bulb hanging high and immediately above the card. Four persons clothed approximately in the same

manner stood around the card, the number of lice wandering out of the circle being noted. After 4 experiments, at the commencement of which the positions of the persons and card were successively altered, we concluded that the lice wandered out in a purely random manner and that Croeker's result must have been due to one or both of the extraneous factors already mentioned.

Conclusions regarding repellants.

The following considerations, in conjunction with my experiments above cited, may serve to explain the apparent contradictions contained in the foregoing statements made by different authors. (1) Certain substances (oils of anise, cloves, eucalyptus, naphthaline, carbolic acid, etc.) do exert a repellant action on lice, this being clearly demonstrated by experiments, conducted in the dark, wherein the insects were given the free choice of wandering towards or away from the substance tested, two pieces of cloth of like texture and size being placed side by side, the one being impregnated with the substance and the other not, the insects, at the start, being placed in the space between the two pieces of cloth. (2) Hungry lice placed on ordinary cloth may wander away from it in search of warmth and food. If a repellant is dropped upon such a piece of cloth the subsequent scattering of the lice from it may be falsely attributed to the action of the repellant alone. (3) When a repellant is dropped upon an infested cloth the lice frequently remain attached to it; they seem to prefer to face it and remain clinging to the cloth. (4) Tests of repellants conducted in the light do not give a fair measure of their effect because the instinct of the insects to flee from the light may overcome their desire to avoid the repellant. (5) Conversely, hungry insects will feed upon the skin in spite of the presence of repellants upon it, their behaviour in this case being comparable to that noted under (3) where the instinct to remain clinging to cloth is stronger than the instinct to avoid the repellant. (6) The negative evidence previously cited (p. 489) can largely be explained in the light of this conflict of instincts on the part of the insects, the stronger instinct overcoming the weaker. (7) It is therefore difficult to attach importance to the action of so-called repellants *in practice,* the evidence indicating that hungry lice will attach themselves to man and feed upon him in spite of them. I believe that these substances protect man because they act in the main as insecticides and not as repellants. (8) There is no proof that lice are more attracted to some persons than they are to others; where this appears to be the case it may be owing to a variety of extraneous factors.

SUB-SECTION I. EXPERIMENTS WITH PEDICULICIDES AND REPUTED REMEDIES.

The following records relate to experiments conducted by various authors including the writer, the different observations being accompanied by numbers in the first column to facilitate reference. The insecticides tested are mostly given in alphabetical order, and the attempt has been made to condense the records as far as possible through the use of signs and abbreviations. These are explained at the head of the tables. It remains to be noted, however, that the fractions $\frac{3}{5}$, $\frac{5}{5}$, etc., accompanied by the words "survived," "killed," or the like, serve to denote the number of insects tested in individual experiments; thus "$\frac{3}{5}$ survived" means that 3 out of 5 insects survived exposure to the insecticide.

A. Experiments with *corporis* (Nits and Lice)[1],

Experiments wherein *corporis* were *immersed* in various insecticides, usually *in vitro*.

Methods. In my experiments the nits tested had been laid on hair during the preceding 24 hours. The insecticide was poured upon the nits placed in small covered glass dishes whence they were removed with fine forceps after exposure, drained on filter paper, and placed at 30° C. to see if they hatched. The exposure was timed with a stop-watch.

The other authors cited in the table (Peacock excepted) do not state how their experiments were conducted.

Ref. No.	Insecticide used	At ° C.	Stage tested n. = nits l. = lice	Result + = killed in ′ = mins. ± = some killed in o = survived exposure of ″ = secs.	Authority. Key to ref. at end of table
1	Acetic acid, pure	—	n.	+ 15′ [of no practical import]	S.
2	Alum, 10 %, cold	—	l.	○ 48 hrs. Two infested shirts soaked, afterwards rinsed in water and worn	P.
3	Anise, oil of, in 30 % alcohol	—	n.	+ 2 hrs	S.
4	Anisol	—	l.	+ 2 hrs	S.
5	Benzine	19°	n.	○ 60″ $\frac{3}{5}$ survived	N.
6	,, ...	19°	n.	○ 90″ $\frac{5}{5}$,, ...	N.
7	,, ...	19°	n.	○ 10′ $\frac{3}{5}$,, ...	N.
8	,, ...	—	n.	± 25′ $\frac{5}{10}$,, ...	S.
9*	Carbolic acid, 2½ %	19°	n.	○ 2½′ $\frac{4}{5}$,, ...	N.

* Add: 3—5 % carbolic acid in soap solution kills l. and n. in 2 hours (Hase 1916 *a*).

[1] The term "lice" is used throughout the tables to denote the active stages.

Ref. No.	Insecticide used	At °C.	Stage tested n. = nits l. = lice	Result + = killed in ± = some killed in ○ = survived exposure of ′ = mins. ″ = secs.	Authority. Key to ref. at end of table
10	Carbolic acid, 2½ %	19°	n.	○ 5′ — survived	N.
11	,, ,, ,,	19°	n.	○ 5′ $\frac{4}{6}$,, ...	N.
12	,, ,, ,,	19°	n.	+ 10′ $\frac{5}{5}$ killed	N.
13	,, ,, 3 %	—	n.	± 60′ ·? [not all killed]* ...	H.
14	Carbon bisulphide	21·5°	n.	○ 1′ $\frac{5}{5}$ survived	N.
15	,, ,,	21·5°	n.	○ 3′ — ,, ...	N.
16	,, ,,	21·5°	n.	+ 10′ $\frac{3}{3}$ killed	N.
17	Chloride of lime, 7 %, cold	—	l. n.	+ 24 hrs. Two infested shirts soaked, pieces bearing 50–100 nits cut out, rinsed and worn 13 days	P.
18	Creolin, 3 % ...	—	n.	+ 25′	S.
19	Cresol, 1½ %, cold	—	l. n.	+ 60′ Six infested shirts soaked, afterwards pieces bearing 50–100 nits were cut out, rinsed and worn 13 days	P.
20†	Cresol, 5 %, and soap	—	n. l.	+ 30′	N.
21	Cresol	—	n.	○ 30′	K. & F.
22	Cyllin emulsion, 5 %	12–15°	n. l.	○ 30′	K.
23	Ether	19°	n.	○ 10′ $\frac{2}{4}$ survived	N.
24	,, ...	—	n.	○ 17′ $\frac{4}{5}$,, ...	N.
25	,, ...	—	n.	± 60′ $\frac{3}{1^3}$,, ...	S.
26	Lysol, 2 % ...	21·5°	n.	+ 5′ $\frac{5}{5}$ killed	N.
27	Mercurial ointment (white precip.)	—	n.	+ 24 hrs	S.
28	Oils (essential)‡				
29	Peru balsam, 30 % in alcohol	—	n.	○ 2 hrs	S.
30	Petrol	—	l.	○ 30″	Hi.
31	,, ...	—	l.	+ 60″ [doubtful]	Hi.
32	,, ...	19°	n.	○ 60″ $\frac{1}{4}$ survived	N.
33	,, ...	19°	n.	○ 1½′ $\frac{1}{4}$,, ...	N.
34	,, ...	19°	n.	○ 10′ $\frac{2}{4}$,, ...	N.
35	,, ...	—	n.	○ 5–25′ survived, on shirt. Lice killed	P.
36	Petrol and soft soap, equal parts, 10 % emulsion	—	n.	+ 1½ hrs	S.
37	Petroleum ...	—	l.	+ 1½′	Hi.
38	,, ...	—	l.	± 60″ [some recovered 2 hrs later]	Hi.
39	,, ...	19°	n.	± 20′ $\frac{1}{8}$	N.
40	Petroleum, erude, 0·75 % in soapy water	32°	l.	± 30′ on 2 shirts, some survived 7 days after, kept at 4·4° C.	P.
41	Sublimate, 10 %...	—	n.	+ 3 hrs [no pract. import]	S.

* Doubtful if properly immersed.

† Add: 3–5 % Cresol soap solution kills n. and l. in 1 hr, 1 % solution in 4 hrs; the soap per se exerts no influcnce (Hase 1916 *a*).

‡ *Kinloch* (1915, pp. 1038–41) found that lice recovered from 1 minute's immersion in oils of carraway, cinnamon, cloves, eucalyptus, peppermint, rue, tansy, thyme, turpentine and wintergreen.

Ref. No.	Insecticide used	At °C.	Stage tested n. = nits l. = lice	Result + = killed in ′ = mins. ± = some killed in ○ = survived exposure of ″ = secs.	Authority. Key to ref. at end of table
42	Sublimate, 0·25 % in 10 % glycerine-water	21·5°	n.	+ 1′ $\frac{5}{5}$ killed	N.
43	Sublimate vinegar (17 % acetic)	—	n.	± 1½ hrs	S.
44	Sublimate vinegar (1 : 299)	—	n.	+ over 30′ needed	H.
45	Sublimate, 0·2 % in vinegar (ordinary)	21·5°	n.	+ 2½′ $\frac{5}{5}$ killed	N.
46	Westoran, 2 % in water	21·5°	n.	○ 5′ $\frac{3}{5}$ survived	N.
		21·5°	n.	○ 10′ $\frac{3}{4}$,, ...	N.
47	Westropol, 2 % in water	21·5°	n.	○ 5′ $\frac{4}{5}$,, ...	N.
		21·5°	n.	○ 10′ $\frac{5}{5}$,, ...	N.
48	Xylol	—	l.	○ 1′	Hi.
49	,, ...	—	l.	+ 1½′	Hi.
50	,, ...	19°	n.	○ 1½′ $\frac{3}{4}$ survived	N.
51	,, ...	19°	n.	○ 2′ $\frac{1}{4}$,, ...	N.
52	,, ...	19°	n.	○ 10′ $\frac{6}{8}$,, ...	N.

References to authors.

H. = Heymann (18. VIII. 15, p. 310).

Hi. = Hindle *MS.*

K. = Kinloch, 1915, pp. 1038–41.

K. & F. = Kisskalt and Friedmann, 1915, p. 397.

N. = Nuttall, unpublished experiments conducted 1915–16.

P. = Peacock, 1916, pp. 56, 55, 41 in sequence as quoted, corrected in *MS. Report*, W. O. I. 1918.

S. = Swellengrebel, 1916, p. 19.

Experiments wherein *corporis* were brought in *contact* with various insecticides.

(*a*) *Experiments in vitro and in boxes.*

Note regarding methods. Castellani and Jackson (1915, pp. 253–255) in their experiments placed the lice together with the insecticide in glass vessels or tin boxes. Knaffl-Lenz (1915, p. 708) placed the lice on cloth impregnated with insecticide. Leitz (1916, p. 1538) experimented with nits placed on pasteboard moistened with insecticide. Galli-Valerio (1916, p. 41) does not describe his method and we assume it was similar to that of Castellani and Jackson for powders and to that of Knaffl-Lenz for fluids. Bacot (IX. 1916, pp. 447–450) experimented in a similar manner to Knaffl-Lenz; he does not state the time of exposure and adds that the results were negative. The authors

cited in the table do not record the temperature at which their observations were made.

N.B. In many contact experiments with volatile substances vapour action necessarily takes place.

Ref. No.	Insecticide tested	Stage tested n. = nits l. = lice	Result + = killed in ± = some killed in ○ = survived exposure of	Authority
53	Alcohol, absolute ...	n.	○ 2 hrs	S.
54	Anisol, 5 %*	n.	○ 2 hrs	S.
55	,, ...	l.	○ 10 hrs	Kn.
56	Antiformin, 10 % ...	l.	+ 20′	S.
57	,, ,, ...	n.	○ 10′	S.
58	Arsenious acid, powder	l.	○ 24 hrs	C.
59	Boric acid, powder ...	l.	○ 7 days	C.
60	Calomel	l.	○ 48 hrs	C.
61	Camphor, powder ...	l.	○ some hrs	G.
62	Carbolineum, concentr.	n.	+ ½ hr [few nits tested]	S.
63	Cineol*	l.	+ 4–6 hrs	Kn.
64	Chinosol, powder ...	l.	○ some hrs	G.
65	Cresol, 3 % powder ...	n	○ 12 hrs	W.
66	,, 5 % soap sol. ...	n.	+ ½ hr [few nits tested]	S.
67	Ether	n.	○ 15′ [nits moistened]	W.
68	Iodoform	l.	± 12 hrs [lice buried in it] ...	K.
69	Methylated spirit ...	n. l.	+ 1 hr 5′	S.
70	Naphthaline	l.	± 8–10 hrs	Kn.
71	,, powder ...	l.	○ some hrs	G.
72	Perolin*	l.	+ 20–25′ [contact essential] ...	Kn.
73	Pyrethrum, powder ...	l.	○ several days [lice with powder in box]	Kis.
74	,, ,, ...	l.	○ some hrs	G.
75	Salicylic acid, powder...	l.	○ 20 hrs	C.
76	Sublimate, dry... ...	l.	○ 24 hrs	C.
77	,, 1 : 1000 sol.	n. l.	○ 2 hrs	S.
78	,, ,,	l.	+ 8 hrs	G.
79	Sulphur, powder ...	l.	○ 48 hrs	C.
80	Xylol	n.	○ 15′ [nits moistened]	W.
81	Cresol, 5–7·5 % ...	l.	○ Pieces of blanket sprayed with cold solution (2 pints per blanket) and rolled up. Lice alive after 3 days. (Costly!)	P.
82	,, 10 %	l.	+ Ditto. Lice dead after 1 day	P.

* Commercial preparations. Anisol = Methylphenylether.

References to authors.

C. = Castellani and Jackson, 1915, pp. 253–5.
G. = Galli-Valerio, 1916, p. 41.
K. = Kinloch, 1916, p. 790.
Kis. = Kisskalt, II. 1915, p. 154.
Kn. = v. Knaffl-Lenz, 1915, p. 708.
P. = Peacock (*MS. Report*, W. O. I. 1918).
S. = Seitz, 1916, p. 1538.
W. = Widmann, VIII. 1915, pp. 289–298.

(*b*) *Experiments on clothing and straw conducted by Peacock* (*MS. Report*, W.O. I. 1918 (Exps. 81, 82), VII. 1916, pp. 41, 50 (Exps. 83–87)).

Ref. No.	Insecticide tested	Form of Experiment	Result + = all lice killed ± = some killed ○ = survived for
83	N.C.I. powder (see ref. 428, p. 537)	Verminous shirt, dusted ...	+ in 3 hrs
84	Ditto	Verminous shirts in bundles of 10, dusted	+ in 3 days
85	Ditto	Straw on floor infested with 500 lice, dusted. 3 clean men slept on the straw 8 hrs later. [Men acted as traps]	± overnight. Six living and 6 dead lice found on men next morning
		Same straw re-dusted and 2 men slept on it on second night	no lice found on them
86	"Powder of heavy oil residue (sulphonated) talc and aloes"	Verminous shirts, dusted	○ 9 days
87	"White mercury powder" (advertised)	Ditto. 26 g. dusted on 4 infested shirts	○ 4 days

(*c*) *Experiments on Man.*

1. Under conditions supposedly simulating the natural.

Note. The following experiments were carried out by Bacot (IX. 1916, pp. 447–450) by the method described on p. 507 in connection with the effect of insecticide vapours. The lice were confined near the body in gauze and wire cells containing lint treated with the insecticide to be tested. No experiments were made with nits.

Ref. No.	Insecticide tested	Result + = killed. ± = some killed. ○ = survived
88	Cresylic acid	immobilized in 3 hrs, all dead next day
89	Cytisine	,, ,, 3 hrs. ? killed
90	Iodoform	,, ,, 4 hrs. Mostly killed
91	Naphthaline	+ 3 hrs
92	Vermijelli	○ 9 hrs

2. Under more natural conditions of experimental infestation.

Ref. No.	Insecticide tested	Form of Experiment	Result	Authority
93	N.C.I. powder (see ref. 428, p. 537)	Blanket sleeping-bag infested with 700 lice. Author slept therein after dusting 2½ oz. of N.C.I. on his shirt, back and front, on riding breeches at fork and down knees. Socks replaced puttees on feet. Shirt opened and sleeves rolled back to elbows. On entering bag, soon felt lice crawling on him. He was only bitten on wrists and ankles	Next morning found 155 dead lice in socks, 30 dead lice below knees of breeches, 1 dead louse on thigh and none on shirt. Concluded that N.C.I. kills and deters	Peacock, VII. 1916, pp. 54, 55, also *MS. Report*, W.O. I. 1918
94	Blue ointment and soft paraffin (equal parts)	1. Smeared on tape worn about ankles, knees, waist, arms and neck	No effect in 2 hrs ...	Ditto
		2. Ca. 1 oz. smeared over whole body before retiring for the night	35/300 lice, previously put on man, found alive next morning	
95	Sulphur	Ca. 3 oz. dusted all over garments, especially seams, but not outside khaki. Experimenter infested himself with 300 lice	Useless when acting only overnight. Was badly bitten and could not sleep during experiment lasting overnight. (Sulphur has no effect per se, see pp. 497, 550)	Peacock, *MS. Report*, W.O. I. 1918
96	Sulphur and soft paraffin	2 oz. applied to skin from neck to ankles, at seams, etc. Experimenter infested himself with 100 lice overnight	Insufficient	Ditto
97	Vermijelli ...	2 oz. per man applied as above, overnight	Fairly efficient ...	Ditto
98	Crude tar oil and soft paraffin, 1 : 8	Applied as ointment to body and seams of clothes. Experimenter slept in bag into which he had put 100 lice	Efficient	Ditto

3. Upon naturally infested men.

Ref. No.	Insecticide tested	Form of Experiment	Result	Authority
99	N.C.I. powder ...	2½ oz. per man, 6 infested men tested	After 1 day 60 % of lice dead	Ditto
100	„ „ ...	2 oz. per man, 20 infested men tested. Dusted all over clothing inside uniform	Lice ceased troubling for 3–5 days, then larvae hatched out	Ditto
101	Cresol 2 % in soft paraffin and crude mineral oil, 2 : 1	Applied as ointment to body and seams to 35 infested men	Fairly efficient, apparently expelled lice	Ditto
102	Cresol 2 % in crude mineral oil, water and soap (3 : 2 : 1)	Applied as ointment as above to 35 men	Ditto	Ditto

4. With Impregnated Clothing.

Tests conducted under practical and experimental conditions.

Ref. No.	Insecticide tested	Form of Experiment	Result	Authority
103	Ol. bettulae 30 % in alcohol 96 %	Clothes steeped therein 15′, wrung and dried ca. 15′ at room temperature. Tested on lousy Austrian soldiers: (*a*) beneath and (*b*) outside infested underclothes	Under both conditions (*a*) and (*b*) lice disappeared from body surface in 24 hrs and none found for 3 days. Effects on man nil. Effect said to be lasting	Lobaczewki, 1915, p. 373
104	Carbolic acid (crude) 5 %, and soft soap equal quant.	Flannel shirt steeped therein, wrung and dried, it absorbed 500 c.c. of solution. Produced no skin irritation by contact. Lice put in chiffon pockets inside shirt	Shirt pediculicidal for 6–7 days, effect waned but smell persisted. Author thought method promising	Bacot, IX. 1916, p. 450
105	Ditto	Light cotton undershirts, impregnated as before and worn beneath flannel shirts, were supplied by the British Women's Patriotic League to troops. Given a fair trial on over 100 soldiers under campaigning conditions	Somewhat mitigated louse infestation for ca. 14 days, produced no skin irritation and men thought well of them. Value doubtful in view of results obtained and cost	Bacot, 20. XII. 1917 (personal communication)
106	Phenol 2½ %, or carbolic acid 2½ %	Similar shirts to the foregoing are being distributed by some agencies or sold in shops. Some of the shirts are made of such loose texture (butter muslin) that Bacot finds lice traverse them, so they give little mechanical protection; lice can bite through the more densely woven fabrics, but not when they are carbolized The Queen Mary's Guild supplies thicker, unbleached, closely woven undergarments which without impregnation impede the biting of lice mechanically	Carbolic acid might irritate the skin more in hot than in temperate climates [These impregnated clothes are still being tested but they may be regarded merely as palliatives]	Ditto
107	Naphthaline and sulphur, 10 % of each, dissolved in benzol or petrol	Butter-muslin vests and drawers steeped therein, dry quickly in air. Worn next the skin they cause no irritation. Renewed as required. Cost 4*d.* a garment in 1915. [May be regarded as an experiment]	Used extensively since June 1915, it is reported with benefit as treatment and preventive	Gunn, 1917, p. 579
108	Calcium monochlorcresol 7 %	Khaki impregnated therewith	Found fairly efficient against attack but of no use when men are heavily infested. Condemned as produced skin irritation and smell disagreeable	Peacock, *MS. Report*, W.O. I. 1918
109	Copper monochlorcresol 4 %	Underclothes impregnated therewith tested in 15 experiments, effect found to last 7 days		

Experiments wherein *corporis* were exposed to various vapours and gases.

(*a*) *Experiments in vitro or in boxes.*

Notes on methods employed. Authors, other than those specified below, do not state how they performed their experiments unless this is mentioned in the table. Most authors fail to mention the temperature at which they tested the insecticides, this being a serious omission since temperature exerts a great influence on vapour tension. Reports on experiments which do not state the conditions are practically valueless for they fail to give even an approximate measure of the concentration in which the insecticide was employed. A number of highly defective observations (Fränkel, III. and IV. 1915, etc.) are therefore omitted from the table, although some very crude observations are recorded.

Knaffl-Lenz (1915, p. 708) placed lice on cloth in 100 c.c. tubes corked at both ends. Fine tubes passing through corks in the ends of the larger tubes admitted a known concentration of pediculicide vapour from an adjoining flask in which the insecticide was heated.

Legroux (1915, pp. 470–473) exposed lice to vapours in 2 litre belljars, the insects being placed on muslin on one side and $\frac{1}{20}$ c.c. of the insecticide upon the other side within the vessel. The lice were observed for 1–20 hrs, and were regarded as dead if they remained motionless on one spot. Legroux notes that some lice recovered after 1–20 hrs where the exposure was short. He tested the vapours at 16° and 33° C., these being temperatures recorded in clothing.

Nuttall (unpublished experiments, 1915) placed nits laid at most 24 hrs before (on cloth or hair) upon little metal benches resting in circular glass dishes, measuring 5 cm. across and 2 cm. in depth, which contained an insecticide that had been poured in to a depth of ca. $\frac{1}{4}$ cm. The bench surface stood about $\frac{1}{2}$ cm. above the surface of the fluid whose evaporating surface was uniform throughout the series. The dishes were covered with glass plates so that the space was saturated with vapour at ca. 15° C. Unexposed fertile eggs of the same lot served as controls for each experiment.

Report (1915, pp. 53–58) relates to Russian experiments made (*a*) with various vapours of reagents of which 15 drops were placed on cotton hung 4 inches above open glass dishes containing lice, (*b*) with different powders. As the available review of the Report does not state if the powders were brought in contact with the insects or not, these experiments are not mentioned in the subjoined table.

Widmann (18. VIII. 1915, pp. 289–298) relied on the stoppage of intestinal peristalsis in lice as evidence of the insects' death, but he was wrong in doing so (see this volume, p. 183), and I therefore exclude his experiments from the table. He experimented with only 2–4 nits with each vapour without mention of control nits to prove that they were fertile; therefore only his negative results are cited.

Wulker (1915, p. 628) relied upon the movements of the embryo in the nit as a sign of death, this being a test of very doubtful value. In common with many authors, he does not state how he determined that the lice were actually killed.

Teichmann (1917) placed lice and nits in glass dishes wrapped in cotton wool (the parcel was put under bedclothes in one experiment), in a well sealed room of 2120 cb. ft. capacity treated by hydrocyanic acid gas.

Baumgarten (1917) exposed lice (and nits?) to saturated naphthaline vapour delivered by a tube from a retort into a small iron lined box and killed the insects in 10–15 minutes at 40° C. This constitutes his "new method" which need not detain us further.

Zupnik (IV. 1915, p. 371; v. 1915, p. 565) made his experiments in 10 cm. long test-tubes, the insecticide being placed on a linen strip near the cotton plug, the lice upon a linen strip at the bottom of the tube. Some experiments were conducted differently as specified in the table.

Experiments, by various authors, in which *sham death* does not appear to have been excluded, are omitted from the table.

Ref. No.	Vapour or gas tested	At °C.	Stage tested n. = nits l. = lice	Result +=killed in '=mins. ±=some killed in "=secs. ○=survived exposure of	Authority. See key to refs. at end of table
110	Acetic acid 4·3 vol. %	—	l.	+ 5 hrs	K.-L.
111	,, 11·1 ,,	—	l.	+ 8′	,,
112	,, —	—	n.	○ 5 days	Zu. 2
113	Acetic acid and ether —	—	n.	○ 1½ hrs	,,
114	Ammonia 3·2–5 vol. %	—	l.	○ 6 hrs	K.-L.
115	,, 11·1 ,,	—	l.	± after some hrs 30 % killed	,,
116	,, (25 % sol.) —	—	l.	+ 2′ (in test-tube)	P.
117	,, —	—	l.	+ 1 hr	F.
118	,, —	—	l.	○ after some hrs	Zu. 1
119	Amyl alcohol —	—	l.	○ after some hrs	,,
120	Anisol 1/20 c.c. per 2 L. space	16°	l.	○ 20′, only immobilized	L.
121	,, ,, ,,	33°	l.	± 12′, 60 % survived	,,
122	,, —	—	l.	± 10′, mostly killed, some recover in 24 hrs	Fr.
123	,, —	—	l.	○ 13½′ (23 insects)	B. & B.
124	,, —	—	l.	± 26′, 4/6 survived	,,
125	,, —	—	l.	± 30′, 8/12 ,,	,,
126	,, —	—	l.	+ 45′	F.
127	,, —	—	n.	○ 3 hrs	Zu. 2

Ref. No.	Vapour or gas tested	At °C.	Stage tested n. = nits l. = lice	Result + = killed in ′ = mins. ± = some killed in ″ = secs. ○ = survived exposure of	Authority. See key to refs. at end of table
128	Anisol —	—	n.	+ 10 hrs or over 4/4 killed	W.
129	,, 16 drops in 1500 c.c. space	—	l.	+ 12–24 hrs	Wu.
130	,, ,, ,, ,,	—	n.	○ 12–24 hrs	,,
131	Benzine saturated atmos.	15°	n.	○ 5′	N.
132	,, —	—	n.	○ 3 hrs	Zu. 2
133	,, —	—	l.	± 1½′, 8/36 survived	B. & B.
134	,, —	—	l.	± 17′, 1/6 ,,	,,
135	,, —	—	l.	+ 15′, 12/12 killed	F.
136	,, 4 drops in 1500 c.c. space	—	l.	+ 12–18 hrs	Wu.
137	,, 1 litre in 1 cbm. space	—	l.	+ 24 hrs	S.
138	Benzol —	—	n.	○ 3 hrs	Zu. 1
139	Benzyl chloride 1/20 c.c. per 2 L. space	16°	l.	○ 35′, only immobilized	L.
139*a*	,, ,, ,,	33°	l.	± 25′, 40 % survived	,,
140	Camphor —	—	l.	○ 1 hr	J.
141	,, —	—	l.	+ 6 hrs	G.
142	,, —	—	l.	○ many hrs	K. 1
143	Camphorated alcohol —	—	l.	± 2–18 hrs, 14/70 and 14/86 survived	S. & F.
144	,, oil 6 drops in 1500 c.c. space	—	l.	+ (?) 4 hrs	Wu.
		—	n.	○ 4 hrs	,,
145	Carbon bisulphide saturated atmos.	15°	n.	○ 3′	N.
146	,, ,, 5 % sol.	—	n.	+ 60′	Zu. 2
147	,, ,, 10 % sol.	—	n.	+ 30′	,,
148	,, ,, 240 c.c. per 1 cbm.	—	n.	+ 2 hrs	N. & H.
149	,, ,, —	—	l.	+ 6′	F.
150	Chinosol —	—	l.	+ 20 hrs	G.
151	Cocculus (alcoh. extr.) —	—	l.	○ some days	Zu. 1
152	Creolin, 8 % heated —	40°	n. l.	+ 10′	M.
153	,, 10 % in soap sol. —	45°	n. l.	+ 15′ (recommended in practice)	,,
154	Cresol, 3 % powder —	—	n.	○ 1½ hrs	Zu. 2
155	,, ,, —	—	n.	○ 12 hrs, 2 nits tested	W.
156	,, ,, —	—	n.	+ 2 days, 3/3 nits killed (too few to make certain)	,,
157	Ether saturated atmos.	15°	n.	○ 5′	N.
158	,, aethilic —	—	l.	+ 30′	F.
159	Formalin —	—	l.	+ 42′	,,
160	,, —	—	n.	○ 15′, 4 nits tested	W.
161	,, —	—	l.	+ 6 hrs	Wu.
162	,, —	—	n.	○ 6 hrs (Peacock, I. 1918, states that formalin vapour has no effect on lice)	,,
163	Formic acid 2·1 vol. %	—	l.	+ 25′	K.-L.
164	,, 3·2 ,,	—	l.	+ 10′	,,
164*a*	Hydrocyanic acid gas 1 %	—	n. l.	+ 2 hrs	T.
164*b*	,, ,, 2 %	—	n. l.	+ 1 hr	,,
165	Illuminating gas —	—	n.	○ "useless"	K. & F.
166	Iodoform —	incubator	l.	○ survived many hrs	K. 1
167	,, —	—	l.	○ ,, for days	K. 2
168	Lactic acid, 20 % sol. —	—	l.	○ survived some days	Zu. 1
169	Lysol, 15 % sol. —	—	l.	○ ,, ,, ,,	,,
170	Methyl anisol 1/20 c.c. per 2 L. space	16°	l.	± 45′, 80 % survived	L.
170*a*	,, ,, ,, ,,	33°	l.	± 12′, 40 % ,,	,,
171	Naphthaline powder —	16°	l.	○ 45′, only immobilized	,,
172	,, ,, —	33°	l.	+ 30′, 100 % immobil. and killed	,,
173	,, ,, —	—	l.	○ 1 hr	J.
174	,, ,, —	—	l.	○ 3 hrs	Zu. 2
175	,, ,, large amount	—	l.	+ 12 hrs or more	Wu.
176	Naphthaline in alcohol 1/20 c.c. per 2 L. space	16°	l.	○ 30′, only immobilized	L.
177	,, ,, ,, ,, ,,	33°	l.	+ 30′, 100 % immobil. and killed	,,

Ref. No.	Vapour or gas tested		At °C.	Stage tested n. = nits l. = lice	Result +=killed in '=mins. ±=some killed in "=secs. ○=survived exposure of	Authority. See key to refs. at end of table
178	Naphthol	—	—	n.	○ 5 days (2 nits tested)	W.
179	α-Naphthol	—	—	n.	○ 5 days (3 nits tested)	,,
	Oils (essential)					
180	,, anise	—	—	l.	+ 24 hrs	R.
181	,, bergamot	—	—	l.	+ 24 hrs	,,
182	,, caraway	—	—	l.	○ some hrs	K. 1
183	,, ,,	—	—	l.	+ 24 hrs	R.
184	,, cinnamon	—	—	l.	○ some hrs	K. 1
185	,, ,,	—	—	l.	+ 24 hrs	R.
186	,, cloves	1/20 c.c. per 2 L. space	16°	l.	+ 6 hrs, immobilized and 100 % killed	L.
187	,, ,,	,, ,,	33°	l.	± 1¾ hrs, immobilized and 80 % survived	,,
188	,, ,,	—	—	l.	○ some hrs	K. 1
189	,, eucalyptus	1/20 c.c. per 2 L. space	16°	l.	± 2 hrs, immobilized and 40 % survived	L.
190	,, ,,	,, ,,	33°	l.	± ½ hr, immobilized and 20 % survived	,,
191	,, ,,	—	—	l.	+ 2-18 hrs (vapour filtered through cloth; in tube)	S. & F.
192	,, ,,	—	—	l.	+ ? hrs (cloth saturated and placed 4 days in open at 15° C.; in tube)	,,
193	,, ,,	—	—	l.	○ some hrs	K. 1
194	,, ,,	—	—	l.	+ 24 hrs	R.
195	,, ,,	—	—	n.	○ 24 hrs	H. 2
196	,, fennel	16 drops in 1500 c.c. space	—	l.	+ ? 1 hr	Wu.
197	,, ,,	—	—	n.	○ 1 hr	,,
198	,, ,,	—	—	l.	+ 24 hrs	R.
199	,, lavender	—	—	l.	+ 24 hrs	,,
200	,, lemongrass	1/20 c.c. per 2 L. space	16°	l.	± 1 hr, immobilized, 20% survived	L.
201	,, ,,	,, ,,	33°	l.	+ 35′, immobilized, 100% killed	,,
202	,, peppermint	,, ,,	16°	l.	± 45′, immobilized, 40 % survived	,,
203	,, ,,	,, ,,	33°	l.	+ 35′, immobilized, 100% killed	,,
204	,, ,,	—	—	l.	○ some hrs	K. 1
205	,, rue	—	—	l.	○ some hrs	,,
206	,, sage	1/20 c.c. per 2 L. space	16°	l.	± 2 hrs, immobilized, 80 % survived	L.
207	,, ,,	,, ,,	33°	l.	± 45′, immobilized, 40 % survived	,,
208	,, tansy	—	—	l.	○ some hrs	K. 1
209	,, thyme	—	—	l.	○ some hrs	,,
210	,, turpentine	—	—	l.	○ some hrs	,,
211	,, ,,	—	—	l.	+ 24 hrs	R.
212	,, ,,	—	—	n.	○ 5 days	Zu. 2
213	,, ,,	—	—	n.	○ 6 days (3 nits tested)	W.
214	,, wintergreen	—	—	l.	○ some hrs	K. 1
215	,, wormwood	—	—	l.	+ 24 hrs	R.
216	Paraffin [liq.]	—	—	n.	○ 3 hrs	Zu. 2
217	Petrol	saturated atmos.	15°	n.	○ 5′, 5/5 nits survived	N.
218	Petroleum	,, ,,	15°	n.	○ 15′, 4/4 nits survived	,,
219	,,	—	—	l.	+ 24 hrs	R.
220	Phenol	—	—	n.	○ 1½ hrs	Zu. 2
221	Pyrethrum	—	—	l.	○ 1 hr	J.
222	Sabadilla (alcohol. extr.)	—	—	l.	○ some days	Zu. 1
223	Safrol	1 drop at dist. of 6·5 cm. in tube	—	l.	+ 2 hrs	Fr.

Ref. No.	Vapour or gas tested	At °C.	Stage tested n. = nits l. = lice	Result + = killed in ′ = mins. ± = some killed in ″ = secs. ○ = survived exposure of	Authority. See key to refs. at end of table
224	Staphisagria (alcob. extr.) —	—	l.	○ some days	Zu. 1
225	SO_2 3·4 vol. %	—	l.	+ 12′	K.-L.
226	,, 5 kilo per 100 cbm.	—	n.	+ 1 hr	H. 1
227	,, 2 vol. %	—	l. n.	+ 2 hrs	N. & H.
228	,, 6 %	—	l.	+ 5–6 hrs	Z.
229	,, 6–18 %	—	l.	± (5–6 hrs ?)	Fri.
229*a*	,, 6-18 %	—	n.	○ (5–6 hrs ?)	,,
230	,, (burned CS_2) —	—	n.	± 24 hrs, 2/17 n. survived	S.
231	,, (burned S, 2·6 kilo per 100 cbm.)	—	n.	± 18 hrs, 3/25 ,, ,,	,,
232	,, ,, 1·6 ,, ,,	—	n.	○ 18 hrs, 30/40 ,, ,,	,,
233	,, ,, 3·2 ,, ,,	—	n.	○ 18 hrs, 32/40 ,, ,,	,,
234	Tobacco decoction —	—	l.	○ some days	Zu. 1
235	,, smoke —	—	l.	+ ? 15′ [only immobilized probably]	Wu.
236	,, ,, —	—	n.	○ ? 15′	,,
237	Trichloraethylene —	—	l.	+ 30′	F.
238	Tricresol (3 %) —	—	l.	○ 1 hr	J.
238*a*	,, (?) —	—	n.	○ 1½ hrs	Zu. 2
239	Xylol —	—	n.	○ 3 hrs	,,

References to authors.

B. & B. = Bordas and Bruère, 1915, pp. 628–633.
F. = Felix, 1915, p. 647.
Fr. = Fränkel, S., v. 15, p. 301.
Fri. = Friedmann, I. 16, p. 333.
G. = Galli-Valerio, 1916, p. 41.
H. 1 = Heymann, 8. III. 15, p. 253.
H. 2 = Heymann, 18. VIII. 15, p. 312.
J. = Jeanneret-Minkine, 1915, p. 134.
K. 1 = Kinloch, 1915, pp. 1038–1041.
K. 2 = Kinloch, 1916, p. 790.
K. & F. = Kisskalt and Friedmann, 1915, p. 397.
K.-L. = v. Knafft-Lenz, 1915, p. 708.
L. = Legroux, 1915, p. 470.
M. = Muto, 1915, pp. 499–508.
N. & H. = Nocht and Halberkann, 1915, p. 626.
N. = Nuttall (hitherto unpublished).
P. = Pregl, 1915, p. 465.
R. = Report, 1915, pp. 53–58.
S. & F. = Sergent and Foley, VI. 15, p. 378.
S. = Swellengrebel, 1916, pp. 17 et seq.
T. = Teichmann, 1917, p. 303, rev.
W. = Widmann, VIII. 15, pp. 289–298.
Wu. = Wulker, 1915, p. 628.
Z. = Zabel, 1915, cited by Friedmann, l.c.
Zu. 1 = Zupnik, IV. 15, p. 371.
Zu. 2 = Zupnik, V. 15, p. 565.

(*b*) *Experiments with Insects present on Clothing or Man.*

1. On Verminous clothing.

Ref. No.	Insecticide tested (vapour or contact)	Experimental conditions	Result	Authority
240	Ammonia, 25 %	4 litres evaporated by Flügge lamp into $3\frac{3}{4}$ cbm. space of Amsterdam disinfection waggon (5 litres evaporated in $2\frac{2}{3}$ hrs by burning 1100 c.c. of spirit, temperature attaining 35° C. in space)	Nits killed in 1–3 hrs	S.
241	,, ,,	Sprinkled on dry clothes in box (mattresses were treated 4 hrs)	Nits and lice killed in 1 hr	P.
242	,,	Clothes soaked therewith, rolled up in cloth and placed on floor	Lice survived $\frac{1}{2}$ hr exposure	Z.
243	Benzine	40–50 c.c. sprayed on clothes in metal boxes	All lice "dead" in 15–20′ [surely some immobilized only, see Exps 131–2]	Ren.
244	CS_2	200 c.c. atomized per cbm. in Amsterdam disinfection waggon. Nits in cotton plugged tubes twixt clothing	3/10 of nits survived 24 hrs, nits killed in 48 hrs	S.
245	,,	800 c.c. per cbm. sprayed on clothes in metal box. (Men engaged suffered slight toxic effects. Odour soon vanishes. Method of Kais. Ges.-Amt.)	Nits killed in 24 hrs	S.
246	Formalin	Evaporated by Flügge lamp at 40 × strength used for house disinfection	10/25 of nits survived 24 hrs	S.
247	,,	Lice on underclothes. No further particulars	Lice survived 2 hrs	M.
248	SO_2 (Clayton), 2·5 %	Test lice and nits hung with effects in fumigation hut used by Captain Gair (17 lots of insects tested)	Lice killed after 7 hrs exposure, 1 nit out of many survived and louse successfully raised	B. 2
249	,, ,, 3·1 %	ditto	Lice killed after 7 hrs exposure, 2 nits survived but hatched tardily	B. 2

2. On Man.

(*a*) *Under conditions supposedly simulating the natural.*

Note regarding methods. Swellengrebel (1916, pp. 16–29), like Gross, Nocht, and others, found that tests conducted in vitro are liable to be fallacious. He therefore tested the effect of insecticides and repellants on his arm beneath a sleeve tightened at the wrist and near the axilla. Young lice were placed in a tube and the insecticide alongside so that

its vapour only penetrated into the interior of the tube. The lice were exposed for periods up to 24 hrs. Unless all of the insects were killed I have entered them as "survived" in the table. Swellengrebel believes that no vapour is sufficiently insecticidal for practical purposes.

Bacot (IX. 1916, pp. 447–450), in his experiments, used small wire framed cells covered by gauze and tied in a row close together. The cells were worn against the body. Known quantities of insecticide were placed on lint in some cells (contact cells) whilst others contained no insecticide (control cells). The cells were worn for 8–12 hrs a day and the results recorded. The lice in the control cells were subject to the *vapour* emanating from the contact cells (the results with the contact cells are cited on p. 498 under contact experiments).

Ref. No.	Insecticide tested (vapour)	Experimental conditions	Result	Authority
250	Acetic acid, strong	See note above (Swellengrebel), 10 c.c. acid used	Lice killed in 4½ hrs	S.
251	,, ,, 50 %	ditto	Lice survived 24 hrs exposure	S.
252	Ammonia, 25 %	See note	,, ,, 10 ,, ,,	S.
253	Anisol	ditto, 10 c.c. used	,, ,, 13 ,, ,,	S.
254	Cresol	ditto	,, ,, 13 ,, ,,	S.
255	Cresylic acid	See note above (Bacot)	Lice mostly survived 2×10 hrs exposure	B.
256	Cytisine*	ditto	Lice (10 %) survived 2×10 hrs exposure	B.
257	Globol	See note (Swellengrebel), used 17 g.	Lice survived 13 hrs exposure	S.
258	H_2S aqueous sol.	See note, solution renewed every 1½ hrs	,, ,, 6 ,, ,,	S.
259	Iodoform*	See note	Lice (10 %) survived 2×10 hrs exposure	B.
260	Lausofan	See note, 5½ g. used	Lice survived 24 hrs exposure	S.
261	,,	No particulars	Lice killed by 3–5 hrs exposure	W.
262	,,	,, ,,	Nits killed by 6 hrs exposure	W.
263	Naphthaline	See note (amount not stated)	Lice survived 6 hrs exposure	S.
264	,,	ditto	Lice mostly survived 10 hrs exposure	B.
265	,,	,,	Lice mostly survived 2×10 hrs exposure	B.
266	Naphthaline ointment	Lice in box, no particulars	Lice only killed after "a long time"	H.
	Oils (essential)			
267	,, anise	See note, amount not stated	Lice survived 6 hrs exposure	S.
268	,, bergamot	See note, 15 c.c. used	,, ,, ,,	S.
269	,, turpentine	See note, amount not stated	,, ,, ,,	S.
270	Pyrethrum	Dusted on clothes, lice in box, on person	Even the best powder almost useless	H.
271	Texan	2 sachets on back and breast as recommended by Gross	Lice survived 6 hrs exposure	S.
272	Vermijelli	See note (Bacot)	Lice mostly survived 9 hrs exposure	B.

* Too costly for practical use.

(*b*) *Experiments upon Verminous Men.*

Note regarding methods. The method of testing the insecticide is mostly stated in the table. The Report (1915, pp. 53–58) herein cited relates to tests carried out on 51 persons in Russia, the insecticide being rubbed on the body and clothing.

Ref. No.	Insecticide tested (vapour or contact)	Experimental conditions	Result	Authority
274	Anisol	Sprayed and dusted on 2 lousy men, amount valued at ca. 4 shillings	No apparent effect overnight	R.
275	Camphor	Bags of camphor worn under shirt	Exerted but slight effect	Rep.
276	Cyclohexanone* (sold in Germany as "Lausofan")	20 % powder on men's bodies and clothes or in bed when wrapped up	Most lice killed in 2–3 hrs	W.
276*a*	ditto	20 % powder or spray on body and clothes, injuring neither. Author has treated 500 men in bed in 5 hrs in Göttingen Prisoners' Camp	Lice and nits killed in 5 hrs	M.
277	Formalin, 10 % (commercial)	Sprayed twice in succession on all clothing. Men can put on clothes at once as good atomizer scarcely wets. If damp, shake and brush. May be necessary to rip seams to spray [therefore practically useless]	Author claims that lice and nits are killed as found in 2 months' practice	O.
278	Mercurial ointment, 15–20 % + naphthaline	Applied to skin and clothes; 3 applications caused dermatitis	Lice killed	Rep.
279	Naphthaline	Bags worn under shirt. To be effective had to be renewed every 3 days	Lice killed	Rep.
280	Oil of eucalyptus	About 1 c.c. per square of 125 cm. sprinkled on clothing of 8 lousy men living with other lousy persons. Repeat treatment after 8 days	No lice found on treated clothes after 24 hrs but young lice appeared after 8 days (nits are therefore not killed)	S. & F.
280*a*	,, ,,	See note above table re Methods	Merely stupefied lice for 1–2 hrs	Rep.
281	Petroleum and turpentine	ditto	Found ineffective	Rep.
282	Sabadilla vinegar with 10 % Peru balsam	ditto	Exerted but slight effect	Rep.
283	Tricresol powder, 3 %	Recommended by Herxheimer and Nathan. Experiment: 30 g. dusted on 2 heavily infested men	No effect observable after ca. 24 hrs	R.
283*a*	ditto	—	Only kills lice after long exposure	H.
284	Various essential oils and cottonseed oil (equal parts)	See note above table re Methods	Found ineffective	Rep.
285	Xylol or creolin (50 %) and cottonseed oil	ditto	ditto	Rep.

* Holste (1915, p. 738) experimented on rabbits and found that cyclohexanone produced no effects upon the skin or by inhalation, but it produced conjunctivitis.

References: B. = Bacot, IX. 1916, pp. 447–450; B. 2 = Bacot, *MS. Report*, W. O. I. 1918; H. = Heymann, S. III. 1915, pp. 253–4; M. = Maehold, 1915, p. 645; O. = Ortieoni, 1915, p. 49; P. = Pregl, 1915; R. = Ragg, 1915, p. 176; Ren. = Renault, 1915, p. 206; Rep. = Report, 1915, pp. 53–58; S. & F. = Sergent and Foley, 1915, p. 49; S. = Swellengrebel, 1916, pp. 16–29; W. = Wesenberg, 1915, p. 861, cited by Swellengrebel, 1916, p. 28.

Experiments upon the relative efficiency of various Insecticides, conducted by A. Bacot (*MS. Report*, W.O. I. 1918).

In experiments (Nos. 286–310) small quantities (0·2–0·22 g.) of the preparations were evenly spread, dusted or sprinkled over the surface of pieces of flannel measuring 6 square inches. The lice were confined upon the flannel by a cover of fine gauze (chiffon) which was stitched to the treated surface of the flannel. The latter was then pinned to the experimenter's shirt with the gauze next to his skin, thereby enabling

Ref. No.	Insecticide tested (vapour and contact)	Results: Time when flannel treated before lice put on it					
		1 hr		24 hrs		48 hrs	65 hrs
	Exposure	4½ hrs	6½ hrs	4½ hrs	10½ hrs	10½ hrs	10½ hrs
286	Oxford grease	—	○ 19/20 alive	—	○ 20/20 alive	○ 19/19 alive	—
287	Vermijelli	—	○ 19/19 ,,	—	○ 19/20 ,,	○ 20/20 ,,	—
288	Naphthaline, crude, and Oxford grease, 1 : 3	± 19/20 dead	—	○ 20/21 alive	—	○ 20/20 ,,	—
289	Parasitox, crude, after heating to 120–130° F.	+ 19/19 ,,	—	± 4/20 dead	—	○ 20/21 ,,	—
290	Naphthaline, crude, unwhizzed* and soft soap, 9 : 1	+ 21/21 ,,	—	± 19/21 ,,	—	± 3/21 dead	—
291	Naphthaline, crude, 17·5 % Safrol 1·5 % Oxford grease 80 % Chlor-cresol 1 pt	+ 20/20 ,,	—	○ 19/20 alive	—	—	○ 20/20 alive
292	Naphthaline, crude, and soap emulsion, 1 : 1	+ 20/20 ,,	—	± 4/21 dead	—	—	○ 20/20 ,,
293	Naphthaline, crude, 85 % Soft soap 10 % Kieselguhr 5 %	+ 19/19 ,,	—	+ 20/20 ,,	—	—	○ 20/20 ,,
294	Naphthaline, crude, 17·5 % Safrol 2·5 % Oxford grease 80 %	± 20/21 ,,	—	± 2/22 ,,	—	—	○ 21/21 ,,
295	Naphthaline, crude, 17·5 % Oxford grease 80 % Chlor-cresol 2·5 % 1 pt	+ 20/20 ,,	—	○ 18/18 alive	—	— 4½ hrs exposure	○ 21/21 ,,
296	Naphthaline, crude, 47 % Carbolic acid 2½ % Oxford grease 50 %	+ 21/21 ,,	—	± 7/21 dead	—	○ 19/20 alive	—
297	Naphthaline, crude, 25 % Carbolic acid 2½ % Oxford grease 72 %	+ 20/20 ,,	—	○ 20/20 alive	—	○ 21/21 ,,	—

* For explanation see footnote p. 537.

the lice to feed upon him during the period that the insects were exposed to the insecticide. This method permitted of no discrimination between *contact and vapour* action, but certainly allowed the insecticide to exert its maximum effect.

The protocols of Mr Bacot are dated as follows: Nos. 286–95 (20. III. 17); 296–7 (13. IV. 17); 298–300 (30. XI. 17); 301–3 (10. XII. 17); 304–6 (8. I. 18); 307–10 (28. I. 18); 311–13 (16. XII. 16); 314–19 (undated); 320–1 (31. I. 17); 322–4 (6. III. 17); 325–6 (10. III. 17); 327–8 (13. III. 17); 329–36 (14. XI. 16); 337–8 (30. XI. 17).

Ref. No.	Insecticide tested (vapour and contact)	Results: Time when flannel treated before lice put on it	
		At once 4—5 hrs exposure	20—22 hrs 4—5 hrs exposure
298	Oxford powder	○ 12/12 alive	○ 12/12 alive
299	Naphthaline, crude, and Oxford powder, 1 : 4	○ 11/11 ,,	○ 11/11 ,,
300	Naphthaline, crude	+ 12/12 dead	± 4/12 dead
301	Naphthaline and Oxford powder, 1 : 1	+ 12/12 ,,	○ 13/13 alive
302	Ditto, 3 : 7	+ 12/12 ,,	± 6/12 dead
303	Ditto, 1 : 9	+ 12/12 ,,	± 7/14 ,,

Ref. No.	Insecticide tested (vapour and contact)	Results: Time when flannel treated before lice put on it		
		1 hr 4 hrs exposure	20 hrs 4 hrs exposure	72 hrs 6 hrs exposure
304	Hexachlorethane, 2 pts Vaseline, ½ pt Soft soap, ½ pt	± 14/20 dead rest feeble	± 2/21 dead rest active	○ 19/20 alive
305	Veratrine, ½ % in vaseline	± 12/19 dead rest feeble	± 9/19 dead rest feeble	20/20 feeble
306	Naphthaline, crude, 10 pts Vaseline, 1 pt Soft soap, 1 pt	+ 20/20 dead	± 18/20 dead rest feeble	○ 22/23 alive

Ref. No.	Insecticide tested (vapour and contact)	Results: Time when flannel treated before lice put on it				
	Exposure	1 hr 4½ hrs	20—24 hrs 9½ hrs	44—48 hrs 9 hrs	68—72 hrs 6 hrs	94 hrs
307*	Harrison's pomade	23/37 feeble	8/20 feeble	14/22 feeble	15/15 feeble	—

* Personal communication from Mr Bacot regarding experiments 307–310.

Ref. No.	Insecticide tested (vapour and contact)	Results: Time when flannel treated before lice put on it				
		1 hr	20—24 hrs	44—48 hrs	68—72 hrs	94 hrs
	Exposure	4 hrs	4 hrs		6 hrs	4½ hrs
308	Veratrine, ½ % in vaseline	± 12/19 dead rest feeble	± 9/19 dead rest feeble	--	20/20 feeble	1 dead, 17 feeble, 1 active
	Exposure	5 hrs	4 hrs	5 hrs	5 hrs	
309	Harrison's pomade	± 19/21 dead rest feeble	± 2/20 dead rest feeble	± 5/21 dead but 4 active	± 2/23 dead but 7 active	—
310	Veratrine, ½ % in vaseline	± 5/19 dead rest feeble	± 3/22 dead rest feeble	± 3/22 dead but 1 active	± 4/20 dead but 5 active	—

In Experiments 311–328 (*Vapour and Contact or vapour alone*) small quantities of the preparation (0·2–0·26 g.) were placed in a thin cotton pocket (15 mm. square) which was stitched to a slip of flannel, the lice were confined within an area ca. 47 mm. square by chiffon stitched to the flannel so that the pocket containing the insecticide occupied a central position beneath the chiffon cover. The confined lice could range away to a distance of ca. 16 mm. from the insecticide pocket. The latter was charged with insecticide powder or paste; as some pastes spread, the lice in such cases came in contact with them. Only the most efficient vapours and widely spreading contact remedies killed all the lice. The method was found to be much more delicate than that used in Expts 286–310, and the action of the insecticide was slower. The flannel was pinned to the experimenter's shirt etc. as described for Expts 286–310.

Ref. No.	Insecticide tested	Lice exposed 4 hours		
311	Naphthaline, pure, commercial, finely powdered	20 dead	26 feeble	45 active
312	Ditto, crude, unwhizzed*	65 ,,	14 ,,	12 ,,
313	Ditto, crude and soft soap	55 ,,	23 ,,	13 ,,

Ref. No.	Insecticide tested	Lice exposed 4—5 hours		
314	N.C.I. powder	63 (51 %) dead	44 feeble	17 active
315	Naphthaline, commercial, finely powdered	51 (43 %) ,,	27 ,,	41 ,,
316	Ditto, second sample	61 (59 %) ,,	29 ,,	32 ,,

* For explanation see footnote p. 537.

Tests *a*, *b* and *c* were started 2, 24 and 48 hours after the poekets were anointed (deaths only reeorded).

Ref. No.	Insecticide tested	Lice exposed $3\frac{3}{4}$—4 hours		
		a	*b*	*c*
317	Naphthaline and soft soap, 3 : 1†	83 % dead	50 % dead	43 % dead
318	Ditto, whizzed* and soft soap, 3 : 1†	100 ,,	84 ,,	77 ,,
319	Ditto, unwhizzed, drained* and soft soap, 3 : 1†	97 ,,	87 ,,	87 ,,

Tests *a*, *b*, *c* and *d* were started 1, 48, 144 and 168 hours after the poekets were anointed (deaths only reeorded).

Ref. No.	Insecticide tested	Lice exposed for			
		a 4 hrs	*b* 5 hrs	*c* 4 hrs	*d* 9 hrs
320	Naphthaline, crude, and soft soap, 9 : 1†	97 % dead	69 % dead	22 % dead	63 % dead
321	Ditto, crude, unwhizzed and soft soap, 3 : 1†	100 ,,	87 ,,	16 ,,	81 ,,

Tests *a*—*d* were started at once, 24, 72 and 144 hours after the pockets were anointed.

Ref. No.	Insecticide tested	Lice exposed $4\frac{1}{2}$—5 hours			
		a	*b*	*c*	*d*
322	Naphthaline and Oxford grease, 3 : 1†	76 % dead	13 % dead	0 % dead	3 % dead
323	Naphthaline, erude, with soft soap and Kieselguhr (85 : 10 : 1 pts)†	94 ,,	68 ,,	22 ,,	31 ,,
324	Stoner's Parasite Destroyer (a powder consisting apparently of sulphur, boracic acid, naphthaline and a little sassafras oil)†	76 ,,	31 ,,	0 ,,	0 ,,

Tests *a* and *b* were started 24 and 72 hours after the pockets were anointed.

Ref. No.	Insecticide tested	Lice exposed 5—7 hours	
		a	*b*
325	Naphthaline $17\frac{1}{2}$%, safrol $2\frac{1}{2}$ %, Oxford grease 80 %‡†	27 % dead	0 % dead
326	Naphthaline $17\frac{1}{2}$ %, chlor-cresol $2\frac{1}{2}$ %, Oxford grease 80 % ‡†	24 ,,	0 ,,

* For explanation see footnote p. 537.

† These percentages are somewhat fallacious, because only about 30 lice were used per experiment.

‡ The effects of these mixtures are attributed almost entirely to contact action.

Tests *a* and *b* were started 1 hour and 24 hours after the pockets were anointed (deaths only recorded).

Ref. No.	Insecticide tested	Lice exposed 4½ hours	Lice exposed 12 hours
		a	*b*
327	Parasitox, contains soap (average result with 4 samples)*	7 % dead	12 % dead
328	Vermijelli *†	0 ,,	15 ,,

In Experiments 329–338 (*Contact and Vapour*) pieces of flannel were impregnated with the insecticide (quantity not stated) by being dipped therein and afterwards wrung out. The lice were confined upon the flannel by chiffon through which they could feed, as in Experiments 286–328, when worn next to the skin during the exposure period.

Tests started (*a*) 1st and (*b*) 2nd day after flannel was impregnated.

Ref. No.	Insecticide tested	Lice exposed 18 hours		Lice exposed 20 hours	
		a	*b*	*a*	*b*
329	Monochlor cresol, 7½ % in alcohol‡	9/21 dead	32/32 alive	5/10 dead	16/16 alive
330	Ditto, 5 % emulsified in castor oil soap‡	18/21 ,,	2/26 dead	3/13 ,,	15/15 ,,
331	Cresol soap solution, 5 %‡	8/22 ,,	1/15 ,,	3/15 ,,	15/15 ,,
332	Carbolic acid (crude) soap solution, 5 %‡	12/15 ,,	8/15 ,,	9/15 ,,	15/15 ,,
		1st day	2nd day	1st day	2nd day
		slight sweating		no sweating	

Tests carried out as under Experiments 329–332. Experimenter exercised in room at 37° C. to induce sweating.

Ref. No.	Insecticide tested	Lice exposed 18 hours		Lice exposed 20 hours	
		a	*b*	*a*	*b*
333	Monochlor cresol, 5 and 7½ % in alcohol‡	9/15 dead (5 % sol.)	16/16 alive	5/15 dead (7½ % sol.)	16/16 alive
334	Ditto, 5 % in soap sol.‡	13/16 dead	2/14 dead	3/16 dead	15/15 ,,
335	Cresol soap solution, 5 %	8/15 ,,	1/15 ,,	3/15 ,,	15/15 ,,
336	Carbolic acid (crude) soap solution, 5 %‡	12/15 ,,	8/15 ,,	9/15 ,,	15/15 ,,
		1st day	2nd day	1st day	4th day
		slight sweating		no sweating	

Ref. No.	Insecticide tested	
337	Tar oil, light, crude	Tested flannel after 3 days, killed 20 lice in 4 hrs
		,, ,, ,, 6 ,, ,, 15 ,, 2 ,,
338	Ditto, in soap solution	,, ,, ,, 1–2 ,, ,, lice in 2 hrs
		,, ,, ,, 3–4 ,, ,, ,, 4 ,,
		,, ,, ,, 5 ,, ,, ,, 8 ,,

* The effects of these mixtures are attributed almost entirely to contact action.

† These percentages are somewhat fallacious, because only about 30 lice were used per experiment.

‡ Experiments 329–336 show the influence of slight sweating on the part of the experimenter during the exposure period, the sweating greatly increasing the death rate in lice. All the lice survived on flannel tested on second day after it was impregnated when no sweating occurred.

Various proprietary remedies and nostrums were tested by Bacot (*MS. Report*, W.O. I. 1918) to which we would allude briefly:

Ref. No.

339. W. A. Procter's Parasiticide Paste and Fluid, for application to the skin and clothes. When applied to the skin, lice remained unaffected and were not prevented from biting. Upon clothing it killed lice during 2–3 hrs after it was applied, but it deteriorated greatly in its action after 24 hrs. The amount required to treat a shirt is estimated by Bacot at 400–500 c.c. Would the cost be commensurate with the result?

340. McDougall's Insecticide Powder. Lice dusted with it and confined unfed in a box therewith, lived 72 hrs at room temperature. Tested on flannel worn next the skin, with lice confined thereon by chiffon, it was found to be but feebly insecticidal. There is no evidence that the preparation possesses any practical value. (10. XII. 1917.)

341. S. Crawford's Fluid for the Destruction of Lice. This appears to contain camphor. Lice were confined on flannel slips 3 × 2 inches treated with 0·3 and 0·6 c.c. respectively and worn next the skin for 6 hrs (only 3/20 dead) and 5½ hrs (only 7/22 dead). A feebly acting preparation. The cost probably prohibitive in practice.

342. "No Germo" when tested was found to be of little or no use.

343. "Para-quit" found to have practically no effect. Supplied in the form of ointment, liquid and soap. Probably contains oil of sassafras (Bacot states that this oil emulsifies with soft soap and keeps for 2–3 weeks when the emulsion breaks down).

344. "Parastik" found less effective than "Parasitox." (See No. 327.)

345. Huxley's "Khaki Trench Powder" contains naphthaline.

346. Maw's Preparation, consisting of 9 essential oils and naphthaline, evaporates too rapidly to be of use.

347. Harrison's Pomade (vide Expts 307, 309). Apparently contains veratrine (vide Expts 308, 310), a highly toxic alkaloid so that it should not be applied to the abraded skin. It kills slowly, vide p. 549, No. 460.

B. Experiments wherein *Phthirus pubis* were exposed to various Insecticides.

The insects, mostly adults, were *immersed* in the fluid insecticides, or, in a few instances, exposed to the effects of their *vapours* at ca. 16° C. The experiments were made on three lots of insects obtained in large numbers from heavily infested soldiers in Cambridge in July and August 1915. The lice were tested by me in batches of 2–5 at a time, either immediately or within 1–4 hrs of their removal from the men. The insects were handled as little as possible, being left clinging to hairs. Some preliminary experiments with nits proved unsatisfactory as very few of the untreated control nits hatched in the thermostat at 30° C.,

it being subsequently found that a very much larger proportion hatched when carried on the person. Experiments on nits therefore still require to be carried out. The exposures were timed by a stop-watch and the immersed insects were removed with a fine brush and quickly dried on filter paper. The method of testing vapours is described on p. 501.

Ref. No.	Insecticide used	Result + = killed in ′ = minutes ○ = survived exposure of ″ = seconds im. = immobilized
348	Benzine	+ 1′
		+ 5′ by *vapour*
349	Carbolic acid, 4 %	○ 1½′ im., recovered in ½ hr, lively after 2 hrs
	4 %	○ 2′ and still moving
	4 %	○ 5′ im. in 3′, recovered and lively after 1½ hrs
	2 %	○ 1½′ im. but recovered and lively after 1⅔ hrs
	2 %	○ 1′ ,, ,, ,, ,, ,,
350	Carbon bisulphide	+ 1½′ im. at once, remain clinging to hair
		+ 1⅙′
		+ ½′
		+ ¼′
		+ 3′ by *vapour*
351	Ether	+ 1½′ im. in 1′, released hair and straightened legs out quickly
		+ 1′ ,, ½′ ,, ,, ,, ,, ,,
		+ 1′
		○ ½′ released hair, but moving feebly after 47′
		○ ¼′ ,, ,, ,, fairly active after 48′
		+ 5′ by *vapour*
352	Lysol, 2 %	+ 5′
		○ 3′ lively after 1½ hrs
353	Petrol	+ 2′
		○ 1½′ im. in 1′
		○ 1′ im. but recovered in ½ hr
		+ ½′ (perhaps feeble to start with)
		○ 5′ im. but moving 3½′ after removal from *vapour*
354	Petroleum	+ 5′ im. in 3½′ and dead in 1⅓ hrs
		○ 1½′ and still moving
		○ 1′ active after 2′
		○ ½′ ,, ,,
		○ 15′ began moving ½′ after removal from *vapour*
355	Sabadilla vinegar	○ 6′ active 11′ after removal
		○ 5′ moved for 3½′, alive but feeble after 1 hr
356	Staveacre decoction	+ 5′
357	Sublimate, 0·2 % in glycerine-water	○ 4′ im. in 1′ but lively again 1⅙ hrs after removal
		+ 4′ im. in 2′
358	Sublimate, 0·2 % in table vinegar	○ 2′ still moving
		○ 4′ im. in 2⅔′ but fairly lively after 1¼ hrs
		○ 5′ active 20′ after removal
359	Terebene (pure)	+ 5′
360	Vermijelli, 2 %	+ 5′
361	Water (as control)	○ 45′ though some ceased moving in 1′
		○ 60′ one active, others torpid for a time
362	White hellebore decoction	○ 5′ lively after 1 hr
363	Xylol	○ ⅓′ moved feebly after 37′
		○ ¾′ ,, ,, ,, 48′
		+ 1½′
		+ 2′ struggled. im. in 2′, released hair, dead 30′ later
		+ 3′ ,, ,, ,, ,, ,,

Of the insecticides tested benzine, carbon bisulphide, ether and xylol obviously killed *pubis* most rapidly.

SUB-SECTION II. PEDICULICIDES AND REMEDIES RECOMMENDED IN PRACTICE.

Historieal. In the *Book of Quinte Essenee*[1] (written in 1460–70) mercury mixed with saliva, etc., is recommended "to distrie lics"; for this purpose take a little mercury "mortifie it wiþ fastynge spotil, medle it wiþ a good quantite of poudre of stafi-sagre [lice-banc], þanne put it in to a great quantite of brennynge water [spirits of wine], þanne waische all his body...or ellis þe heed [head] where þe icche *and* þe lies ben." The quintessence or burning water (alcohol) alone is also recommended as a cure for itch and lice.

Moffett, writing in 1590 (see bibliogr.), after citing many ancient writings in which lice are mentioned, quotes a number regarding the treatment for lice. From lack of time I have not as yet been able to verify these references, but I have added some dates, etc. in brackets since it is of interest to learn when certain remedies for lice were first employed:

Pliny (A.D. 23–74) prescribes for lice the application of staveacre and red arsenic; mustard seed; garlic with vinegar and nitre; oil of radish in old cases; oil, tar, sweet gums, black helleborc, etc. For nits he recommends alum and vinegar, calf's bile and vinegar, goat's milk, nitre and Terra Samia smeered on, powder of harts-horn drank in wine. *Avieenna* (A.D. 980–1036) prescribed mercury with oil of roses, wild staveacre with arsenic. *Haly Abbas* (*Liber totus med.* 1523) recommended (1) mercury bruised with staveacre seed and oil of wild saffron, anointing the body therewith morning and evening after bathing; (2) an ointment, similarly used, and consisting of long birthwort, pine leaves, oil of lupin and mercury; (3) alum, wormwood, santonicum, or mugwort; (4) birthwort, red arsenic and oil of Ben, to be applied as an ointment overnight, rubbing the body next morning with bran and barley meal (which would allay irritation). *Abenzoar* prescribed for nits on the head the anointing of the hair with lesser centaury and alkitrium; "Brimstone in Vinegar takes away Nits, also Oyl mingled with Lye." *Gilbertus Anglieus* (ca. 1290. His *Compend. med.* was published, 1510, in London) "burns Leeches and Styrax Calamita together, and with these and Hogs bloud, he prepares an excellent Unguent," apparently for crab-lice. Moffett mentions the occurrence of crab-lice ("wild lice," "Pediculus ferus") upon the beard and eyebrows, etc. and says it is best to shave the hair of the infested

[1] Already cited on p. 417 q.v. The italicized letters are added by the transcriber; þ=th.

parts and that useful applications are the bile of the bull, calf, capon or partridge with juice of centaury and mercury. Saffron and lye are stated to be commonly used for body-lice in Ireland and Iceland. *Amatus Lusitanus* (1511–?) prescribed bitter lupins iii pugils, seeds of staveacre ii pugils and strong vinegar q.v., boiled, as a wash for the body which is afterwards dried and anointed with staveacre, red arsenic (sandaracha), nitre, vinegar and oil of radish. *Marcellus* (1536) "doth very much commend Hogs dung mingled with wine and juice of Roses; also to anoynt with Honey and Sal Armoniack, but chiefly Oyl of Radishes with a strong lie." *Hildegardis* (Saint Hildegardis) "provides a lie made of Date-stones, which being mingled with Oyl of Radish roots, will kill the Nits. *Ardonus* mingles some sublimate of Quick-silver with spirit of wine: And he saith also, that if the head be first wet with Hens-eggs, and then with the joice of Sowbread, or Sea-water, that the Nits will never breed again. *Gilbert* (*loc. cit.*) an English man highly commends (for nits) the gall of any Creature as also all bitter things, cleansers, and Aromatical Drugs, with the juice of Marigolds." *Constantinus* (ca. 1600) gives two prescriptions for lice: (1) mercury, ashes, litharge, vinegar and oil mixed; (2) "pine-tree juyce, sea-water, staveacre, arsenic nitre, oyl of wilde Saffron." Johannes de Rupescissa prescribes Mercury and Aquae vitae mixed with powdered Staveacre worn on a girdle about the loins to kill lice.

James's *Medical Dictionary* (1743–5, cit. Knott, 1905, p. 194), after referring to the need of cleanliness, combing the hair, etc., advises applications composed of various combinations of the following remedies: wormwood, staveacre, rue, horehound, lesser centaury, and oak ashes in washes and ointments. Ointments, etc. of oils of bitter almonds, rue, bay, staveacre; myrrh, powdered aloes, vinegar and salted lard; mercury; staveacre, red arsenic, salt, olive oil and vinegar; staveacre, powders of nitre, white hellebore, oil of bitter almonds. *Sennertus* [lived 1572–1637] recommends a lotion of birthwort, lupin, leaves of pine and cypress boiled in water; and besides other remedies stated to be most effective he mentions an ointment prepared from powdered staveacre, white hellebore, mercury, hog's lard and bay oil. The Dictionary points out the dangers of mercury, and black soap is recommended as equally effective for anointing the skin.

Linnaeus (1767, p. 1016) recommends the following for killing head- and body-lice: "Seminibus Veratri, Staphisagriae, Menispermi, Rutae, Apii, Angelicae, Lauri, Croco, Pipere, Ledo, Lycopodio, Pinguicula, Hydrargyro, Gelu, Æstu."

In this heterogeneous collection we can still pick out remedies that are in use to-day. We see that staveacre, vinegar, oil and tar were used 1900 years ago, mercury 900 years ago, sulphur, sublimate, essential oils, storax and alcohol a long time ago, whilst Moffett advises shaving for crab-lice. The use of egg-white for cleansing hair, mentioned by Ardonus, still continues. Saffron and oil of radish seem to have been abandoned as well as blood and bile. The use of blood may perhaps be traced to the statement "For those that breed of man's bloud will die if you smeare them with the bloud of other Creatures." Bile may have been used because it was recorded that lice abandon those with jaundice.

Of recent authors, we find Stevenson (1905, pp. 1–44) supplying a list of remedies against *hog-lice* compiled from different authors: 3 % coal-tar (Peters, 1902), 2 % carbolic acid, benzine, kerosene, whitewash (Niles, 1900); sulphuret of potassium (2–4 oz. per gallon of water, Verrill); pyrethrum and kerosene-emulsion (Lugger); kerosene with linseed or cottonseed oil (1: 2, Oliver, 1896); staveacre decoction (2 oz. to a quart of water, much used in England, and when vinegar is added it is stated to destroy nits); 10 % kerosene-emulsion with 3 % creolin solution applied every 2 weeks, etc. These remedies are to be applied with a broom or spray.

Brunton (II. 1915, p. 298) cites from Brunton's *Pharmacology* (1885, p. 1105): mercury, anise, pyrethrum and staveacre, and (*Ibid.* 1893): chloroform, Cocculus indicus, Dalmatian flowers, essential oils, laurel leaves, petroleum and quassia; finally (1915) he refers to white precipitate ointment (1 : 10) applied to the body or (1 : 5) to the pubis, and staveacre ointment as being usually employed in hospitals. Mense, Prowazek, Popoff, Marzinowsky and Zucker (1915) list the ordinary remedies; the latter holds the original view that strong odours occlude the spiracles of lice. Hase (XI. 1915, p. 156) lists 181 remedies that have been advocated, many being quack and secret preparations which unscrupulous persons have put on the market. Numerous authors mention the stock remedies already mentioned.

Galewsky (III. 1915, p. 285; V. 1915, p. 652) quotes from other authors and records a few unsatisfactory experiments. Nocht and Halberkann (1915, p. 627) suggested the use in the trenches of a spraying fluid containing oil of turpentine and carbon tetrachloride, etc., but they supply no evidence of its efficacy in practice. Swoboda (1915, p. 920) gives a fairly long list of remedies, condemning many because of the adverse opinions expressed by others. He divides the few remedies he

regards as useful into two categories: (*a*) those suited for use on a small scale (camphor, oil of turpentine, black pepper, mercury), and (*b*) those applicable on a large scale (naphthaline, cresol, tar, sulphur, tobacco); he appears to write from a limited knowledge of the subject. Pinkus (1915, p. 239), after mentioning the usual remedies, recommends the trial of balsam of Peru and Perugen as not causing skin irritation, the latter being a cure for scabies and having been found to kill lice in vitro (no experiments described).

To soothe the irritation due to louse bites, Castellani and Chalmers (1913, p. 1580), writing more particularly of *Phthirus pubis*, advise the use of a lotion consisting of calamine, 40 grains to an ounce of water. Oppenheim (1908, p. 332) treats the eczema with talc, zinc ointment and the like, recovery being rapid after the insects have been removed.

The following pages comprise a list of insecticides that have been recommended in practice, the statements regarding their efficacy not being accompanied by other evidence than the experience of the writers quoted. The manner of applying the remedies is frequently not stated. Where such data are lacking, I have sought to supply them, and occasionally add remarks regarding the injurious action, etc., of the remedies. A number of so-called remedies, advocated by authors without any specific statements as to their efficacy in practice, are intentionally omitted.

N.B. To facilitate cross references and avoid confusion with the numbers accompanying the records of Experiments with Insecticides (1–363), the data relating to the remedies that follow are numbered 364–474. The kind of louse for which a remedy has been applied is indicated in each case:

capitis standing for *Pediculus humanus capitis*,
corporis ,, ,, ,, *corporis*,
pubis ,, *Phthirus pubis*.

"lice" stands for active stages of *corporis* and "nits" only refers to the eggs of *corporis* throughout unless otherwise specified.

Authors are only cited by name in the text, the fuller references to the bibliography being given on p. 558.

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364. **Acetic acid** 10 %, or **vinegar**, for *capitis*.

Commonly employed to facilitate the removal of nits from the hair. It does not dissolve the chitinous tubes of the nits but makes it easy to slip them along hair with a fine comb. Warming the

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vinegar is said to be an advantage. The use of vinegar for lice is mentioned by Pliny and subsequent writers (see p. 516) and is frequently referred to in the following pages in connection with the treatment for head-lice.

Busson states that *corporis* recover after a short exposure to it and that it is useless in practice, this being untrue from what is stated above. Expts 110–113: lice are killed by 5–6 hrs but nits resist 5 days' exposure to the vapour. Expts 250–1: lice survived exposure to the vapour of 50 % solution for 24 hrs near the body.

365. **Acetylene gas**, tested on *corporis,* is valueless as an insecticide (Zucker).

366. **Alcohol**, absolute, or strong spirit, for *capitis*, *corporis* and *pubis*.

Alcohol is given as a remedy for lice in the *Book of Quinte Essence* (1460–1470).

For *pubis*: strongly recommended as cheap, simple and effective. The infested person should not be allowed to bathe just before treatment as water dilutes the alcohol and the skin smarts. It is best in any case to rub dry the naturally moist skin beforehand. Spray the alcohol upon the infested region at a distance of ca. 25 cm. and fan the part until the alcohol has evaporated; spray again after 5 minutes and repeat the process a third time in bad cases. The dead lice are now removed readily and the pruritus stops. Give a warm bath. The clothes (shirt and fork of trousers) should be similarly sprayed, but more plentifully; they should not be used for 8–14 days. The lethal effect is apparently due to dehydration as lice may live 5–10′ in alcohol (Oppenheim). For after treatment in case of skin irritation see p. 519.

Eau de Cologne is recommended by Moniez.

For *capitis* Oppenheim recommends the same treatment as that above described.

See also Nos. 449, 474, etc., where it is used as an adjunct or vehicle.

367. **Ammonia**, for *corporis*.

Reports as to its usefulness are contradictory. Fränkel states that it is a good cheap remedy; when strong it kills nits and lice on clothes and bed linen enclosed in a box or bag; he advises a strength of 10–25 %, adding that it is too expensive for use in the present war. Ragg recommends it for killing lice but states that it tarnishes metal buttons, and, when sprayed, irritates the lungs

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and eyes of the personnel unless respirators are worn. Knafft-Lenz reports that lice survive exposure to a 3 % ammonia atmosphere, whilst Busson states that it has no value in practice, lice recovering from short exposures. Swellengrebel describes how 25 % solution, heated with a Flügge lamp (burns alcohol), is vapourized into hermetically sealed chambers (Amsterdam Corporation waggons), clothing being exposed for $2\frac{2}{3}$ hrs; it can also be atomized on clothing confined in metal receptacles; he recommends the method.

Expts 114–118 with vapour are contradictory. Expts 240–242: lice and nits killed by vapour in 1–3 hrs. Expt 239: vapour of 25 % sol. was resisted by lice for 10 hrs when confined near the body.

See also No. 431.

368. **Anisol**, for *corporis*.

This was much praised in Germany at the beginning of the war. Nocht and Halberkann state it was found too expensive and that it did not kill lice in the dilute vapour concentration that was practically applicable. Wesenberg cites *Chem. Zeitung*, 1915, p. 378, as stating that lice recover from its effects after some hours and that it is not harmless to men; it was tried in the Austrian army, found ineffective and stopped. Busson reports that it did not protect him and a nurse against infestation. Bordas and Bruère found it of no value as compared to benzine.

Expt 4: lice immersed in it for 2 hrs were killed. Expt 55: lice in contact with it survived 10 hrs. Expts 120–130: with vapour are contradictory. Expt 253: lice resisted vapour near man's body for 13 hrs. Expt 274: had no effect overnight when sprayed on a lousy man.

369. **Asafoetida**, for *corporis*.

Used and recommended in the Danish war (Prowazek). Scarcely an agreeable remedy. No recent evidence available as to its usefulness.

370. **Benzine**, for *capitis* and *corporis*.

Compresses applied to the head for 15 minutes are used at the Hôpital Militaire Buffon (Renault); method recommended by Letulle and Bordas. Filippini states that its free application to the head followed by putting on an airtight covering produced headache, etc. in Italian soldiers who inhaled the vapour; its use was therefore discontinued. It was found less effective than petroleum and dangerous because of its inflammability.

For killing *corporis* on clothing. The Kais. Gesundheitsamt states that Weyland in the Franco-Prussian war obtained excellent results by exposing clothes to vapour in tightly closed boxes for 2–3 hrs. Busson recommends an exposure of 3–4 hrs in boxes, lice being found to recover from shorter exposures. Letulle and Bordas advise spraying clothing placed in metal cylinders which are then quickly closed. Ragg reckons that 0·5 L. should be sprayed per 100 L. space. Swellengrebel reckons 1 L. per 1·5 cbm. and advises an exposure of 24 hrs, the fluid being atomized into hermetically sealed cases through an opening at the top, the vapour gravitating downward. Eckert states that the box method is unreliable though recommended by authority. In cold weather the clothing must be well aired before use so as to evaporate the benzine; this should not be done near a fire. Ragg advises dabbing the clothes afterwards with $\frac{1}{2}$ % sublimate solution to kill nits (value doubtful).

Soaking ragged lousy clothing in benzine is a method employed at Kaposi's Clinic, Vienna (Pinkus); infested Italian soldiers' clothes have been soaked in benzine contained in barrels (Mendes); the vessels should actually contain enough fluid to immerse the clothing, and, as a large experience has shown, the exposure should not last less than 2 hrs (Muto).

For destroying lice in 1st class railway carriages in France, the fluid is evaporated from dishes standing in warm water; exposure period 24 hrs.

For killing lice on men it is applied to the body beneath the cloak (Renault), or where the men are wounded and cannot be shaved and bathed it is recommended to place 15 drops on compresses put on the breast, back, etc., repeating this every 4 days. (Letulle and Bordas.) Darier (II. 1918, p. 224) states that the Assistance Publique of Paris recommends an ointment consisting of trioxymethylene 1 pt, benzine 10 pts, vaseline 1000 pts, for application to the hairy parts of the body; it should serve for *capitis*, *corporis* and *pubis*.

Expts 5–8: nits survived immersion for 1–25 minutes. Expts 131–137: nits survived 3 hrs exposure to vapour, lice killed in 12–24 hrs with certainty. Expt 243: sprayed on clothing, lice supposedly killed in 15–20 minutes (merely immobilized). Expts 347–348: *pubis* killed in 1 minute by immersion and 5 minutes by vapour.

See also Nos. 426, 431.

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371. **Benzol**, for *corporis*.

Sprayed on clothes, afterwards confined in boxes (as described for benzine, v. supra); it is preferred to benzine by Ragg, who states, however, that the sprayer or atomizer freezes in winter and uniforms become encrusted with benzol which evaporates slowly and may catch fire. Mixed benzol and benzine do not freeze thus. Nits should be killed afterwards by dabbing on $\frac{1}{2}$ % sublimate solution (it is therefore not entirely efficient).

Calomel, see No. 419.

372. **Camphor**, for *corporis*.

Worn in sachets beneath the shirt it was found useless in Russia (Official).

Expts 140–143: lice survive many hours' exposure to vapour. Expts 143–144: lice survived 4–18 hrs exposed to vapour of camphorated alcohol.

See also Nos. 425–6.

373. **Camphorated alcohol**, for *capitis*.

Camphor 1 part in 90 % alcohol (*Brit. Pharm.* 1914). Wash the hair therewith and wrap the head overnight in compresses covered with oilcloth and soaked with van Swieten's solution (see No. 415) of double strength. One application usually suffices (Lagane). Soap and wash well afterwards (Borne, Plique). In treating soldiers, cut the hair short with clippers, rub the fluid on the head with a cloth afterwards wound round like a turban and worn for "some time" (W.O. French Army, 1915).

374. **Camphorated oil**, for *capitis* and *corporis*.

Camphor and olive oil, 1 : 4 (*Brit. Pharm.* 1914). Apply to the head as described under No. 373. After a warm bath and soaping, rub the hairy parts of the body with the oil. Oil the hands of personnel as a prophylactic (W.O. French Army, 1915). Recommended, but procedure not described, by Renault, and by Nicolle and Conseil. See experiments with repellants, p. 488.

375. **Carbolic acid**, for *capitis* and *corporis*.

For *capitis*, $2\frac{1}{2}$ % solution: lay the woman or child (over 5 years old) on her back with the head over the edge of a bed above a basin resting on a chair so that the hair lies in the basin. Pour the carbolic over the hair so that it falls into the basin and sluice it about until all the hair is soaked; sluice for 10 minutes, drain, wring out moderately, swathe head turbanwise in common flannel

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preferably to a towel. Remove the turban after 1 hour, wash the hair or merely let the carbolic dry. The latter is absorbed by hair but does not injure it, on the contrary, it renders the hair particularly soft and silky. Where there is impetigo the carbolic softens the scabs and prepares the site for application of ointment. Whitfield has never seen carboluria result and recommends the method from 12 years' experience in practice, other methods having been tried and found inefficient. Perroncito recommended 1 % solution. Castellani and Chalmers advise 1¼ % solution: soak the hair, wash with soap and water, then apply acetic acid (25 %), using fine comb.

For *corporis*, crude carbolic acid solution in water (strength not stated) is recommended in Russia (Official Instr.), to be applied as described under No. 396.

See also No. 429 (*a*), and under repellants, p. 488.

376. **Carbolic acid** 5 % and **methylated spirit** (1 : 1), for *capitis*.

In very bad cases moisten the hair well as a preliminary, then apply compresses wetted with the solution. Cover the head with tight-fitting bathing-cap for 12 hrs, after which wash, dry, and comb (Allan).

377. **Carbolic acid** 2 %, followed by **olive oil**, for *pubis*.

Used for treatment of very heavily infested soldier's axillae, eczematous inflammation present with hair matted by blood and secretion from scratching. Swabbed with carbolic for 15 minutes, clipped away crusts and hair, dried the part and applied oil. Cured by one treatment (Nuttall, VIII. 15).

378. **Carbolic acid in olive oil** (1 : 40), for *capitis*.

Soak the head at least 72 hrs, then wash. Cited by Shipley as recommended by a nurse.

379. **Carbolic acid pomade** (strength not stated), for *capitis*.

Recommended as application to children's heads (Dubreuilh and Beille).

380. **Carbolic acid** 1 % in 5 % neutral-**glycerine** in water, for *corporis* and *pubis*.

Sponge the patient down quickly with the solution and bathe him in warm soapy water (Plique).

381. **Carbolic acid**, crude, 5 % and **soft soap** (1 : 1), for *corporis*.

Used for impregnating clothes as a preventive. Exps 104, 105: value doubtful. See No. 406 (Lysol).

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382. **Carbolic acid**, crude, 5 % in **soap solution**, for *corporis*.

Expt 20 (footnote): 3–5 % solution killed immersed nits and lice in 2 hrs. Expts 332, 336: some lice survived 18–20 hrs contact with flannel wrung out in the emulsion and worn next the skin.

383. **Carbolic acid** 2½ %, and **phenol** 2½ %, for *corporis*.

Used for impregnating underwear (see No. 106) is merely palliative if that.

Expt 12: carbolic acid 2½ % killed all nits in 10 minutes when immersed. Expt 349: carbolic acid 4 % immobilized *pubis* in 3 minutes but they recovered from 5 minutes' immersion.

Carbolic acid and **naphthaline**, etc., see under Naphthaline (Expts 296–7).

384. **Carbon bisulphide**, for *corporis* on clothing and furs.

The clothing is placed in galvanized iron boxes of 2 cbm. capacity with lids sealed by a water-filled gutter. The CS_2 to the amount of 150 g. is poured into a plate placed on the clothes, which are exposed in the closed boxes overnight at room-temperature. Under experimental conditions 100 g. of CS_2 sufficed to kill lice and nits. The method has given good results in war prisoners' camps in Germany. By evaporating a sufficient quantity of CS_2 in a hermetically sealed room, the same results can be obtained on a larger scale. The method is specially applicable to furs (Kisskalt and Friedmann, Kisskalt, Friedmann).

CS_2 is highly inflammable and there is a danger of explosions. It is poisonous when inhaled but the smell affords a safeguard. Greasy objects should not be exposed to CS_2 because fats absorb it. The method has the advantage of not injuring fabrics and furs and of being applicable without special apparatus. CS_2 diffuses rapidly. (See p. 554, CS_2 used for SO_2 production.)

Expts 14–16: nits immersed therein are killed in 10 minutes but not in 3 minutes. Expts 145–149: the vapour kills lice in 6 minutes, and nits in ½–2 hrs. Expts 244–245: the vapour used effectively in Amsterdam Corporation waggons and boxes, killing nits in 24–48 hrs. Expt 350: *pubis* immobilized at once when immersed in CS_2 and killed in 1½ minutes; killed by vapour in 3 minutes.

385. **Chloride of lime** added to bath, for *corporis*.

A "penny packet" added to water after a hot bath, "lie soaking in it for 5 minutes; the effect marvellous" (J. Cryer, cited by Shipley). It is not stated in what the "marvellous effect" consists.

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386. **Chlorine**, for *corporis* in clothing.

Fränkel states that when dilute it kills lice without affecting fabrics and that it can be applied in rooms. It injures metals.

387. **Chloroform**, for *pubis*. Recommended by Ziamal (1856).

388. **Chloroform-water** (5 : 1000), for *capitis* and *corporis*.

Rubbed on the body and hair (Letulle and Bordas, Renault).

389. **Cinol**, for *corporis*, applied to the skin.

Recommended by Wulker. Tried under difficult conditions in the Argonne by Hornstein who states that the men were continually becoming reinfested whilst various other remedies failed. Cinol applied to the skin after cleansing it every 3–4 days produced no irritation and gave great temporary relief. Effect on lice undetermined.

390. **Cocculus indicus**, for *capitis*.

The powdered fruit, made into an ointment, is sometimes used. It is dangerous when applied to abraded surfaces. Intensely bitter; the poisonous principle is picrotoxin (G. H. F. N.).

Expt 151: lice survived exposure to the vapour for some days. It probably acts by contact.

391. **Creolin** 2–2½ %, for *capitis*, recommended by Perroncito.

8–10 % for *corporis* on clothing, used as a vapour. Muto figures a box whose sides fall apart and in which the clothes to be treated are hung. A little boiler containing creolin solution and heated by a small wood fire is placed to one side with a steam pipe leading into the box. The method is used in the Italian army (exposure period not stated). Alessandrini also recommends the method; he states that the creolin evaporates into the box at 40° C. and that 10–20 minutes' exposure suffices in practice to kill lice and nits. Creolin is non-inflammable, non-toxic, cheap, and not injurious to fabrics.

1 % solution may be used for steeping or spraying infested clothes. It becomes inodorous in 2–3 days and ceases to be insecticidal (Engelhardt).

Expt 18: nits are killed by 25 minutes' immersion in 3 % solution. Expts 152–153: nits and lice exposed to the vapour at 40–45° C. are killed in 10–15 minutes. Expts 101–102: mixed with other ingredients and applied as an ointment to the skin, it is stated to be fairly efficient in abating louse-infestation.

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392. **Cresol solution**, for *corporis* in clothing.

With 50 litres of 2 % solution Legendre steeped the underclothes of 62 men; the clothes were wrung out after 10 minutes (to economize the cresol) and then rinsed twice in water and hung up to dry. The lice (and nits?) are stated to have been killed.

Blankets should be steeped 24 hrs in 5 % solution and then dried and stored 2–4 weeks according to Freemantle as cited by Dore. (It is evident that the steeping or storage period alone would be sufficient.)

Expt 19: 1½ % solution kills lice when immersed therein for 1 hr. Expts 154–156: the vapour had no effect on nits in 12 hrs. Expt 254: the vapour near the human body was resisted by lice for 13 hrs. Expts 81–82: lice survived 3 days on blankets sprayed with 5–7½ % solution, but were killed in 1 day by 10 % solution. Cresol is too costly for this purpose.

393. **Cresol powder** 3–5 %, for *corporis* in bandages.

Talc or wood powder (oak or beech) serves as the vehicle. Recommended by Swoboda.

Expt 64: 3 % powder had no effect on nits after 3 hrs.

394. **Cresol ointment** 3 %, for *capitis* and *corporis*.

After a bath rub the ointment on the hairy parts of the body and brush down with petroleum-lysol-soap emulsion (see No. 455 a). A not very logical form of treatment advocated by Adler-Herzmark.

395. **Cresol-soap solution**, for *corporis* on the body, clothes, boots and leather effects.

Copeman recommends the solution (1½ oz. Jeyes' fluid, 1½ lbs soft soap and 10 gallons of water), having used it for months on troops at Crowborough Camp with good results. The men bathed, then lathered themselves with the solution, especially over the hairy parts, and allowed the lather to dry upon them. Shirts were washed in a solution made with boiling water, and the lather was rubbed in especially along the seams of tunics and trousers where it was allowed to dry.

5 % cresol-soap solution poured into vats is used for soaking clothes that are weighted down by stones. After steeping for 2 hrs the clothes, boots or leather articles are hung up to dry (Uhlenhuth and Olbrich). It may be usefully applied to the body (Kisskalt).

Cresol-soap solution (carbolic acid coefficient 10–12) is supplied

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to the British Army and is used in the strength of 4 oz. per gallon of water for soaking clothes 30 minutes (Lelean).

Expt 20 (also footnote): 5 % solution killed nits and lice immersed therein in 30 minutes; 3–5 % killed in 1 hr; 1 % killed in 1 hr; the soap only useful for cleaning. Expt 65: doubtful. Expts 331, 335: it is moderately insecticidal for lice in contact with flannel wrung out in it and worn near the body. (See p. 582, note to Bacot and Lloyd.)

396. **Cresol** (35 %), **soap** (65 %) and **petroleum**, for *corporis* in clothing.

Efficient, convenient, kills lice and nits quickly, smell clings to clothes and repels lice for weeks. Use it in 10 % watery solution to soak undergarments, apply it with a brush to outer clothes. Soulima and Ebert state it is the best remedy they have found in their Russian experience. The Official Instructions (Russian) recommend its being brushed into seams and folds of clothing which is then dried and brushed to remove dead lice. Underclothes are merely dried after steeping.

Cresol, monochlor. Expts 329, 330, 333, 334: not promising.

397. **Cyclohexanone**, for *corporis* on body and clothes.

German daily press states that when sprayed or applied as powder to the body and clothes of men in bed, it kills lice and nits in 5 hrs and subsequently acts as a preventive (*Pharmaceut. Journ.* 19. VI. 15); cutting kindly supplied by Dr Andrew Balfour who informs me that it (C_6H_{12}) is obtained by the complete reduction of benzine (C_6H_6).

Expts 276, 276*a*: stated to kill most lice in 2–3 hrs, read footnote; a further trial desirable.

398. **Ether**, for *corporis,* condemned as too expensive and inflammable (Fränkel).

Expts 23–25: nits survive immersion for 1 minute. Expt 67: nits survived being moistened for 15 minutes. Expt 157: nits survived vapour 5 minutes. Expt 351: *pubis* immobilized in ½–1 minute and killed in 1 minute, vapour killed in 5 minutes.

399. **Formalin**, for *corporis* in clothing.

Condemned as useless by Zucker and also by Orticoni. 7·5 % solution advocated as a spray for blankets by Dore. Gaud recommends its use adding a solution thereof to a warm permanganate solution in a barrel which serves as a generator (see original).

Expts 159–162: the vapour killed ⅔ lice in 6 hrs but left the nits

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unaffected. Expts 246–247: lice survived 2 hrs and nits 24 hrs exposure to strong vapour when on clothes in a box. Expt 277: spraying the clothes recommended after 2 months' practical experience. Since the seams of clothing may have to be ripped open and the vapour is ineffective, the method scarcely commends itself.

400. **Hellebore**, white, decoction for *corporis* and *capitis*.

An old remedy advocated for use on man and animals (mentioned by Sennertus, 1572–1637; James, 1743; and Linnaeus, 1767).

Expt 362: *pubis* recovered and lively after 5 minutes' immersion.

401. **Hexachlorethane**. Expt 304 too volatile and but moderately efficient. Mixed with other ingredients and tested on *corporis*.

402. **Hydrocyanic acid gas**, for *corporis* in clothing, etc.

Recommended by Lebedeff in the Caucasus, it having been used extensively for destruction of plant-pests in N. America, against plague fleas and vermin on shipboard (see Roberts, 1914, *U.S. Publ. Health Reports*, XXIX. No. 50). Corlette writes that it is used on Australian coasting steamers and railways against vermin, water 1 pint, strong H_2SO_4 12 oz. and coarsely ground Pot. ferrocyanide (or P. cyanide) being used per 1000 cubic feet space.

Lebedeff describes an apparatus consisting of a chamber built of iron pipes or bamboos, planted in the ground, covered with waxed cloth, and provided with a vertically sliding door operated by a string from a distance. The dampened clothes are hung up inside. An earthenware bowl containing H_2SO_4 is placed on the floor and Pot. cyanide q.s. in a filter paper bag is dropped into the bowl and the door slammed. The reaction is over in about 10 minutes. The exposure lasts 20–30 minutes in practice. The chamber is now ventilated by pulling open the door with the string from a distance and similarly opening a ventilator flap at the top of the chamber. Needless to say the personnel must be carefully instructed regarding the dangerous qualities of the gas. The method scarcely appears suited for disinfestation in war times.

Teichmann (1917) states that lice and nits were killed by 1 % of the gas in 2 hrs and 2 % gas in 1 hr in a sealed room (2120 cb. ft), the gas penetrating through bedclothes and cotton wool in which the insects in glass vessels were wrapped. Hydrocyanic acid gas has therefore great penetrating power. After 2 hrs fumigation the room was aired for 15 minutes and could then be safely entered.

403. **Illuminating gas**, does not kill *corporis* (Zucker).

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404. **Iodoform**, for *corporis* on clothing that is being worn.

Prowazek states that it was used in the Danish war and recommended.

Expt 68: some lice survived 12 hrs burial in it. Expt 90: on man, some lice survived 4 hrs contact with it. Expts 166–167: lice resist vapour in vitro for days. Expt 242: lice survived twice 10 hrs exposure to the vapour on man's body; see also Expts 90, 259. Iodoform is therefore of little or no value (see further under No. 428).

405. **Larkspur tincture**, for *capitis*.

Recommended by Sobel as an alternative treatment to that with petroleum and olive oil and applied in the same way (see No. 451).

406. **Lysol** 2 %, with **soft soap**, for *corporis*.

Dore recommends that it be lathered on the skin and allowed to dry.

Expt 26: 2 % lysol solution killed nits in 5 minutes when immersed. Expt 169: lice lived for days exposed to vapour. Expt 352: *pubis* killed by immersion in 2 % lysol solution for 5 minutes. (See p. 582, note to Bacot and Lloyd, and No. 455 *a*.)

407. **Malinin's fluid**, for *capitis* and *corporis*.

This fluid consists of Oleum terebinthinae rossicum, petroleum, pyrethrum, carbolic acid, and Ol. cinnamoni (for details of preparation see Malinin), and it is recommended for the treatment of head-lice and soaking underclothes to keep away body-lice. Shevirov states it was formerly used against mosquitoes in the Caucasus, that it has no injurious effect on the health or skin, but that it irritates the mucous membranes. As it injures rubber it should be applied to clothing by means of a metal spray. (There is nothing to indicate that the complex recipe has any particular virtue.)

408. **Mercury**, for *capitis*, *corporis* and *pubis*.

Recommended for lice in the 11th century by Avicenna, in the *Book of Quinte Essence* (1460–70), by Sennertus (lived 1572–1637), etc., see p. 516.

Unguentum hydrargyri (Mercury or Blue ointment), *Brit. Pharm.*, consists of mercury 30 g., benzoated lard[1] 65 g., prepared suet 5 g. An old remedy for *pubis* infestation which consists in anointing

[1] See footnote to No. 463.

the parasitized parts (Nysten and many others recommend it). Renault advises its application to the pubic and axillary regions only, washing it off after 2 hrs and repeating the treatment daily for a week. It should be lightly applied to the skin for *corporis* (Nysten) or smeared on the scrotum, about the anus and perinaeum of soldiers whose pubic and axillary and head hair has been shaved, to guard against lice generally (Boral). It may be applied to the head for *capitis* in adults but it is often found too irritating (Dubreuilh and Beille). Smearing the seams of clothing with it has been found "of some use" against *corporis* (Meltzer).

The following are other methods of applying metallic mercury as a remedy against lice: (*a*) by wearing it in a sack worn near the body in the form of a "Merkolinschurz" (proprietary?) as described by Blaschko, there being no evidence that this method is of any use in practice whilst several authors condemn it. (*b*) E. R. Hues states that the Chinese mix a $\frac{1}{2}$ oz. of mercury with masticated and ground tea-leaves[1], this being used to impregnate a loosely twisted cotton string which is worn about the neck and renewed once a month, the mercury being "a prompt and specific remedy against lice" (cit. Shipley). (*c*) Mercury incorporated with a plant paste applied to a string and worn about the neck or wrists is stated by Agronom to be used by the Sarts, although it is equally effective when mixed with any fat (cit. Shipley). (*d*) This probably originated the "Asiatic Body Cord" sold by a firm in this country; the loosely woven cord holds together a tallow-like substance having the colour of blue ointment and in which I detected globules of mercury:

"Somerville's Asiatic Body Cord or Trench Plague Remedy," sold at 1*s.* each and marked "Poison." The box bears printed statements that the remedy "completely exterminates lice or body vermin and prevents their lodging on the person or clothing," that it is "approved by the medical profession and is the original and only genuine cord," that it "does its work quickly and thoroughly" and is "our soldiers' best friend in the trenches." It is "simply worn round the waist next the skin."

Objections to mercury. Numerous cases of mercurial poisoning have followed the use of blue ointment and the dangers have repeatedly been pointed out (James, 1743, to Fasal, 1915!) and it seems about time that *the method should be abandoned.* That mercury, corrosive sublimate, and even calomel may produce

[1] See p. 516 where saliva and Hg. etc. are recommended, A.D. 1460–70.

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itching, a variety of rashes, frequently a scarlatinoid eruption, and eczema, is well known. Neisser (1896), however, attributed many of the so-called mercurial eczemas to inferior ointments containing turpentine, fatty acids, nitro-benzol, etc.[1] Dubreuilh and Beille, Renault, and others state what has long been known in practice, that these injurious effects can be partly obviated by soaping and washing off the treated parts 1–2 hrs after each application of mercurial ointment. Blue ointment constitutes at best a filthy method of treatment and the ointment should certainly not be smeared on clothing. The ointments described under Nos. 409, 420, 421 are in any case preferable because less liable to affect the skin.

Expt 94: blue ointment and soft paraffin (1 : 1) applied to a man's skin overnight did not prevent living *corporis* from being found on his person next morning. Blue ointment smeared on tapes worn about different parts of the body and limbs exerted no effect on the lice in 2 hrs.

409. **Mercury, ammoniated.** *Unguentum ammoniati* (ammoniated mercury ointment or "white precipitate ointment"), *Brit. Pharm.*, consists of powdered ammoniated mercury 5 g., benzoated lard 95 g.[2] It is used for *capitis*, *corporis* and *pubis*.

Apart from its more attractive appearances it is stated to be less irritating to the skin than blue ointment. For *capitis* it is applied to the head like blue ointment but should also be used sparingly if at all (Morris, Fasal). It is frequently used for *pubis*. Some time ago I treated a case of severe infestation of the axilla accompanied by eczema; the hair and crusts were partially removed and the ointment applied; a prompt cure followed. For *corporis* infesting typhus cases and patients that could not be shaved, Brauer employed several inunctions with benefit.

Expt 27: nits immersed in ointment were killed in 24 hrs.

410. A powder consisting of Hg. ammoniati 1 oz., Zinci oxidi $\frac{1}{2}$ oz., Magnesii silicatis $\frac{1}{2}$ oz. is recommended for *corporis* as having been found efficient in practice, not being greasy and the silicate forming a good vehicle. The mercury is slowly ionized and the zinc oxide inhibits absorption, being astringent and dehydrating. It has been applied with the best results to "suppurating wounds infested with vermin," there having been no absorption or dermatitis (Moore).

[1] Montgomery, D. W. (1896), Eruptions from mercury, *Med. News*, 21 Nov., repr.

[2] See footnote to No. 463.

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Lelean quotes the same recipe but does not mention Moore. Dore found it very effective on clothes.

411. A mixture of Hg. ammoniati and soft soap (2 : 1) is recommended for smearing the seams of clothing, these being afterwards ironed. For *corporis* (Dore).

412. **Mercury**, **bichloride**, for *capitis*, *corporis* and *pubis*.

Its use against lice was advocated by Ardonus (cit. p. 517) and van Ooteghem (1836, see bibl.). For *pubis* "10 g. in a bath" are used, the immersion lasting half an hour, according to Railliet. For *capitis* in adults, where the lesions are usually dry, and for *pubis*, Dubreuilh and Beille advise the use of 1 : 1000 or 1 : 500 solutions applied after soaping and degreasing the hair. When few *capitis* are present, Borne deems a 1 : 4000 solution sufficient, the head being well soaped and washed. For *pubis* Plique prescribes sublimate compresses applied after a bath, the patient being in bed; when the lice are dead, shave the hair and watch the case for some days. Whilst Teske recommended the application of sublimate solution to the skin for *corporis* as a preventive, Widmann found that a 7 % solution does not prevent the insects from biting, and Kisskalt as well as Meltzer tried it and found it useless. A. G. Levy is cited by Shipley as advising the spraying of a 1 : 1000 solution on clothing, but there is no evidence that this procedure is of the slightest use.

Expts 76–78: lice and nits survive 2 hrs but are killed after 8 hrs contact with a surface moistened with 1 : 1000 solution.

413. **Mercury**, **bichloride**, and **glycerinated water**, for *pubis*.

Recommended by Rabe, the solution containing 0·2 % sublimate. Oppenheim, however, already pointed out in 1908 that this solution acts slowly and is not trustworthy in bad cases; it may produce mercurial stomatitis and dermatitis in some persons.

Expt 42: *corporis* nits were killed by 1 minute's immersion at 21° C. Expt 257: some *pubis* survived 4 minutes' immersion at ca. 16° C. Temperature will doubtless play a considerable part in the rate at which the lice are killed.

414. **Mercury**, **bichloride**, and **vinegar** (sublimate vinegar), for *capitis*, *corporis* and *pubis*.

For *capitis* it constitutes an old tried remedy, being applied after the head has been well soaped and washed. Dubreuilh and Beille refer to the "Copenhagen recipe" as containing 2 : 1000 sublimate. Mense prescribes a strength of 1 : 300 for *capitis*, *corporis* and *pubis*,

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and so do Heymann and Brault. Oppenheim's opinion is adverse to its use as stated under No. 413. Brault treated a case of generalized *pubis* infection successfully therewith, and Mense states that when dabbed on but one application usually suffices either with *capitis* or *pubis*. The skin should be merely moistened; it may become irritated if rubbed. When the solution produces a burning sensation this is due to skin lesions which should be protected by applying vaseline containing salicylic acid. For *corporis* in clothing, Mense advises rubbing it into the seams with a toothbrush, repeating the process at intervals. The remedy is at all events cheap, simple and handy for it can be prepared either from dilute acetic acid (10 %) or ordinary table vinegar. One effect of the vinegar on nits is mentioned under No. 364 q.v.; it perhaps helps the sublimate to penetrate the insects.

Expts 43–45: some *corporis* nits immersed therein for $2\frac{1}{2}$ minutes were killed whilst others required over 30 minutes' exposure.

415. French authorities (Railliet, Brumpt, French W.O.) recommend acidulated van Swieten's solution, 10 parts of vinegar being added to 1 part of the solution, the latter consisting of sublimate 1 pt, water 900 pts, and 80 % alcohol 100 pts, or the amount of sublimate may be doubled. In mild cases one application suffices following upon soaping and washing the head. The French W.O. advises for soldiers that the hair be clipped short and the solution rubbed in with a cloth that is afterwards worn for some hours as a turban.

416. **Mercury, bichloride, vinegar** and **camphorated alcohol**, for *capitis*.

This consists of sublimate 1 pt, vinegar 50 pts, camphorated alcohol 50 pts and water 200 pts, and is recommended by Darier. Apply with compresses soaked therein after soaping the head (Brumpt). The camphor can have little or no effect on the insects, see No. 372.

417. Desmons (*Journ. méd. Paris*, cited by Allan) recommends a but slightly modified recipe for *capitis*, consisting of Tinct. benzoini m. 75, sublimate gr. 15, glacial acetic acid dr. 6, eau de Cologne ad oz. 16. Apply carefully with a cotton pledget.

418. Pinsky in Russia (cited in Editorial XI. 15) recommends a "Campaign jelly" for *capitis* and *corporis* (to be applied to the body), this consisting of sublimate solution (%?) 10 pts, soft soap 15 pts, beef fat and lard each 34 pts and birch-tar 9 pts. A rather filthy preparation.

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419. **Mercury, chloride** (HgCl, calomel), for *capitis* and *pubis*.

It is stated to kill lice readily by Leach (1817). *Calomel pomade*, consisting of calomel 1 pt and vaseline 20 pts is recommended by Lagane for *capitis* where excoriations are present. Dubreuilh and Beille advise it for *pubis* in preference to blue ointment.

Expt 60: lice in contact therewith in a box survived 48 hrs. This does not mean that it may not act when on man.

420. **Mercury, oleate** (5 %) 1 oz. and **ether** 1 oz., for *capitis* and *pubis*.

Apply to head, removing crusts with carbolized oil (Morris).

Castellani and Chalmers give the oleate and ether in the proportions 3 : 1 for *pubis* whose active stages and nits are stated to be thereby killed.

421. **Mercury, oxide**, for *capitis*, *corporis* and *pubis*.

Unguentum hydrargyri oxidi rubri (red mercuric oxide ointment or "red precipitate ointment"), *Brit. Pharm.*, consists of red mercuric oxide in powder 10 g., paraffin ointment 90 g. (*Ung. paraffini* (*B. P.*) consists of hard paraffin 27 g., soft paraffin 70 g., white beeswax 3 g.). Employed by some in preference to blue ointment.

422. Yellow mercuric oxide ointment is recommended for *pubis* by some authors. Fischer used a 1 % ointment for application to the eyelids, a 5–10 % ointment for the head, stating that it cures quickly. It was used by Brault. Renault prescribed a 2 % ointment applied daily for a week in a case of infestation of the eyebrows and lids, thereby killing the lice as they emerge from the eggs which resist when the active stages succumb. Darier (II. 1918, p. 223) advises the abandonment of blue ointment preferring 10 % yellow oxide in vaseline with 1% salicylic acid as it does not cause injury.

423. **Naphthaline** alone in sachets (linen bags) or powder, for *corporis*, was recommended by Blaschko (I. 1915), the sachets containing 30–50 g. per man and being worn about the neck. In conjunction therewith he advised occasionally dusting it on the neck whence it could drop down into the clothing. Axenfeld tried sachets (5–10 g.) worn between shirt and uniform by soldiers in the Galician trenches, apparently with some benefit; the sachets lost 0·1 g. weight per day from evaporation.

Meltzer thought the sachets useful in keeping away lice from clean men. Galewsky used them on cleaned Russian prisoners besides dusting naphthaline about their necks and into their socks; he recommends the method because after 3 weeks but a few lice

reappeared on 3 prisoners only; moreover, whilst 40–50 fleas were present per bed before treatment none were found subsequently. (There is no proof in either of these cases that naphthaline sachets were beneficial; the favourable result may have been due solely to the thorough disinfestation previously practised.)

Busson states that naphthaline (quantity used and how applied not mentioned) did not protect him and a nurse against infestation. An isolated and imperfect observation.

Expt 70: some lice survived 10 hrs contact with a cloth impregnated therewith (temperature?, not tested on man). Expt 91: lice killed in 3 hrs by contact with impregnated cloth worn near man's body. Expts 171–177: the vapour, acting in vitro, killed all lice in 30 minutes at 33° C., but at 16° C. they were merely immobilized; others survived 3 hrs (? temperature). Expts 263–265: the vapour acting near man's body, most of the lice survived 10–20 hrs exposure. Expt 279: the vapour from sachets worn by verminous men, killed lice (all?) but the naphthaline had to be renewed every 3 days to be effective. Expt 300: crude naphthaline impregnating cloth worn near man's body killed $\frac{12}{12}$ lice placed in contact with it immediately after it was impregnated, but cloth impregnated 20–22 hrs previous to placing the lice upon it only killed $\frac{4}{12}$ lice in 4–5 hrs. Whereas the vapour of pure naphthaline, emanating from the substance placed in close proximity to the insects and carried near man's body, killed $\frac{20}{91}$ lice in 4–5 hrs (Expt 311), crude unwhizzed naphthaline in the same period killed $\frac{65}{91}$ (Expt 312: contact took place here for the crude oily substance spreads in fabrics), and similarly, finely powdered commercial naphthaline in Expts 315–316 killed $\frac{51}{119}$ and $\frac{61}{122}$ of the lice respectively.

Comments. These experiments demonstrate (1) that naphthaline is much more powerfully insecticidal either by contact or vapour at the temperature that prevails in clothing than at lower temperatures; (2) that its range of action is very limited, the insects only being killed when exposed to concentrated vapour or to actual contact with the substance; (3) that owing to evaporation naphthaline must be renewed at intervals of about 3 days; (4) that crude naphthaline acts more powerfully than the pure substance, owing to its oily character which causes it to be imbibed by fabrics; (5) the impurities in crude naphthaline are in a measure insecticidal and they retard the evaporation of naphthaline with which they

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are intermixed (as do soap or vaseline, v. infra). Bacot's experiments prove that "crude unwhizzed" naphthaline, which includes tarry oils, is much more potent than "crude whizzed" or "crude drained" naphthaline[1]. See further under Nos. 424–431, and experiments with repellants, p. 488.

Objections to naphthaline: many men object to the odour and skin lesions may be produced thereby, especially when coarser particles come in contact with the skin (Löhe). As ordinarily employed it does not appear to do harm, but it should not be allowed to come in contact with the eyes (Axenfeld). It may produce irritation of the kidneys (Meltzer).

424. **Naphthaline ointment** (5 % in vaseline), for *corporis*, applied to the skin, is recommended by Blaschko (I. 1915) and praised by Kisskalt and Friedmann who state, however, that it must be used plentifully to be of use.

425. **Naphthaline** and **camphor** sachets (for *corporis*), containing these ingredients in the proportions 9 : 1, the amount per man being $5\frac{1}{3}$ oz., are recommended by Pasini for soldiers in Italy. The sachets are worn outside the underclothes on breast, back, waist and ankles (Corsini). See No. 427.

426. **Naphthaline**, **camphor** and **benzine** sachets or powder (sawdust as vehicle), for *corporis*, are recommended by Noel.

427. **Naphthaline** and **creosote** sachets (for *corporis*) are recommended by Pelizzari for use in the Italian army, being worn as with No. 425, between the underclothes and uniform, not against the skin. The sachets contain coarse naphthaline 100 pts and creosote 2 pts, the amount per man being ca. 4 oz. (Corsini).

428. **Naphthaline** 96 pts, **creosote** 2 pts and **iodoform** 2 pts, known as **N.C.I.** powder and used in the British Army, for dusting on the clothes and body (for *corporis*).

The directions are to dust 1 oz. per man inside all clothing once weekly, it being best if the men roll themselves tightly in their blankets overnight. The lice are stated to be mostly dead next

[1] Naphthaline comes into the market in various degrees of purity. Pure naphthaline is much more expensive than the impure. Mr Bacot (3. III. 1918) informs me that the crude product, obtained in the preparation of coke, is collected in a still. The impure form is dark brown, oily, and therefore tends to cake. This product is centrifugalized ("*whizzed*") to partly purify it, when it appears pale brownish-grey but is still oily and inclined to cling. The "*drained*" product, likewise crude, only differs from the last in being somewhat paler and drier. "*Unwhizzed*" naphthaline represents the first non-centrifugalized product.

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morning (Lelean). Peacock refers to it as the best all round insecticide he has tested; he advises dusting 2 oz. upon the shirt and trousers every 4 days. From observations on 5 men, Peacock concludes that the effect of keeping off lice lasts 3–5 days; he describes it as useful in the trenches, a good killer and repellant but a poor expellant, meaning that it does not appear to drive out lice that are established on the person. He observed no ill effects on himself and 3 men after using it a week, except that it produced itching or smarting at the fork; it should therefore be used in moderate amount in this region or be replaced by an insecticide ointment. Peacock advocates dusting it on the outside of the underclothes and not upon the skin. The essential agent in the mixture is naphthaline, but as Bacot has found its range of action limited it should be well distributed so as to exert its effect by contact.

Expt 93: N.C.I. dusted on a man and acting overnight killed many lice. Expts 99–100: it killed lice but not nits on man. Expts 83–85: dusted on shirts it killed lice in 3 or more hours. Expts 314–316: it killed about as well as naphthaline but caused more enfeeblement among the lice. N.C.I. and commercial naphthaline evaporate at about the same rate; there is no evident advantage in the admixture of creosote and iodoform. The naphthaline alone suffices, acting quickly but only for a short time because of loss by evaporation. Its lethal power as a vapour only extends to a distance of 2–3 inches from the substance as Bacot has proved.

429. **Naphthaline (crude) with various admixtures.** These preparations were subjected to tests as to their relative efficiency, on behalf of the War Office, by Bacot, using active stages of *corporis* as described on pp. 509 et seq.

(*a*) With carbolic acid and Oxford grease. Expts 296–297: it killed all lice after $4\frac{1}{2}$ hrs on freshly impregnated cloth, but had no effect after an interval of 148 hrs.

(*b*) With Oxford grease. Expts 288, 322: it killed 76–95 % of the lice in $4\frac{1}{2}$–5 hrs at first but had no effect after an interval of 24 hrs.

(*c*) With Oxford powder. Expts 299, 301–303: the powder decreases the efficiency of the mixture in proportion as the amount of naphthaline falls.

(*d*) With Oxford grease and chlor-cresol. Expts 295, 326: lice

put on cloth immediately after it was impregnated were all killed in $4\frac{1}{2}$ hrs, but none were killed after an interval of 24 hrs; 24 % were killed by 5–7 hrs exposure after an interval of 24 hrs and none after an interval of 72 hrs.

(*e*) With safrol and Oxford grease (Expts 294, 325) or with chlor-cresol added thereto (Expt 291) the impregnated cloth had no effect on lice after 24 hrs; an unpromising result.

(*f*) With soap emulsion. Expt 292: still killed $\frac{4}{21}$ of the lice after an interval of 24 hrs.

(*g*) *With soft soap.* Expt 290: $\frac{3}{21}$ of the lice killed after an interval of 48 hrs. Expts 317–319: only the lice that were killed are recorded from the protocols, but many were feeble and practically dying; in tests made 48 hrs after anointing the cloth 27 %, 13 % and 3 % of the active lice survived in the three experiments. In Expt 320: a test made after an interval of 168 hrs resulted in the death of 63 % of the lice after an exposure of 9 hrs, whilst in parallel Expt 321 81 % were killed by crude unwhizzed naphthaline and soap. If Expts 311, 312, 315, 316, made with naphthaline only, are compared with the foregoing, made with the soap mixture, it will be seen that the addition of soap greatly increases the potency of the naphthaline; Bacot attributes this to the spreading of the soap increasing the vapourizing area and bringing some contact action into play by its spreading in the cloth. When Bacot sweated in consequence of exercise, whilst harbouring the experimental lice on his person, the lethal effect was increased.

(*h*) *With soft soap and Kieselguhr* (=diatomaceous earth, as vehicle). Expts 293, 323: all lice were killed in $4\frac{1}{2}$ hrs after a 24 hrs interval in one case whilst 31 % were killed in 4–5 hrs after an interval of 144 hrs in the second case. The Kieselguhr seems therefore to be a useful ingredient since the evaporation of naphthaline is thereby further retarded.

(*i*) With vaseline and soft soap. Expt 306: records $\frac{18}{20}$ of the lice killed in 4 hrs after a 24 hrs interval.

Comments. The mixture (*b*) has been supplied to the troops in France, but experiments demonstrate that it is inferior to naphthaline alone, the effect of the grease being practically nil. Oxford grease or powder[1] added to naphthaline acts merely as a diluent. Peacock (*MS. Report*, W.O. I. 1918) reports that lice

[1] Merely a proprietary name. In no way associated with the town of Oxford.

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survived for $8\frac{1}{2}$ days in shirts dusted with Oxford powder and that he found it of no value when tested on a naturally infested man. There is therefore no apparent reason why these preparations should be used in conjunction with naphthaline; they are merely ballast. None of the insecticides tested by Bacot equalled naphthaline, especially the crude "unwhizzed" product (see footnote, p. 537). Good results were however obtained with Parasitox (see Expt 289).

The mixture of naphthaline (*g*) with soft soap alone or (*h*) with diatomaceous earth is found to offer distinct advantages. Mr Bacot informs me (26. II. 1918) that he and Colonel Monckton Copeman, as the result of their experiments, recommended a mixture consisting of crude unwhizzed naphthaline and soft soap, 3 : 1, for use in the army; that the proportions were subsequently altered to 9 : 1, and still later diatomaceous earth was added by the military authorities so that the preparation might be used in hot climates (at 35° C.). Bacot states, however, that the original 3 : 1 mixture withstands this temperature perfectly well. N.C.I. powder in the same way retains its potency longer when mixed with soft soap. The soft soap by spreading in fabrics distributes the naphthaline so that it comes in contact with the insects and it prevents the wastage that occurs when it is used in powder form.

430. **Naphthaline-and-sulphur**-steeped undergarments have been distributed to soldiers by certain agencies, it is claimed with benefit (see No. 107).

431. **Naphtho-benzol-ammonia** mixture, for *corporis*, consists of 5 % naphthaline in saturated solution of ammonia gas in benzine. When heated to 40–50° C., it is stated to give good results in the Italian army when applied as a fumigant to piles of clothing. The solution may also be added to powder for individual use (Izar, cited by Galli-Valerio, and by Grixoni).

432. **Naphthol oil** (5 %), for *capitis*.

Useful, but should not be applied to white hair which becomes irrevocably stained yellow (Pinkus).

433. ***β*-naphthol pomade** (5 % in vaseline), for *capitis* and *pubis*.

Recommended for *capitis* on children where excoriations are present (also for crab-lice Dubreuilh and Beille, Lagane); afterwards washing with Panama wood decoction (Brumpt, who gives 5–10 % pomade).

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434. **Naphthol** 6 % in 90 % **alcohol**, for *pubis*.

Recommended for use on soldiers by Borne.

435. **Oil of anise**, for *corporis*.

5 % mixed with some indifferent oil, worn in sachets to which a few drops are added at 1–2 day intervals. Kisskalt states anise may harm the respiratory system and cause loss of appetite. Bertarelli advises it, mixed in the proportion 4 : 6 with 96 % alcohol as a preventive. Soldiers abhor the smell of it after a time (Meltzer).

Expt 180: lice killed by its vapour in 24 hrs. Expt 267: lice survived 6 hrs exposure to its vapour on man's body[1].

436. **Oil of bergamot** 30 % in spirit, for *corporis*.

Recommended in the last Balkan war by military surgeons (Prowazek). Too expensive for practical purposes. Expts 181, 268: throw doubt on its value[1].

437. **Oil of birchtar** (Ol. bettulae) 30 % in 96 % alcohol, for *corporis*.

An old tried remedy in ointment for skin diseases. Steep clothes in the solution, air-dry for 15 minutes. Clothes feel slightly greasy and softer; they can be worn for weeks and keep off lice (Lobaczewski).

Expt 103: when applied to verminous men it caused lice to disappear from the body surface for 3 days.

Oil of cloves[1].

438. **Oil of eucalyptus**, for *corporis*.

Place drop-wise on clothing so that it is well distributed especially along the seams; apply ca. 1 c.c. per 125 square cm. Treat clothing again after 8 days to kill larvae that emerge from unkilled nits.

It has no effect even on a child's skin. When inhaled in quantity and for a long time, the vapour causes malaise, vomiting and diarrhoea. In Algeria it costs 3–6 francs a kilo, Australia supplies it at 2·50 francs. Caution: clothing is easily set on fire for some hours after treatment (Sergent and Foley). Eucalyptus oil is also recommended by the Kais. Gesundheitsamt.

Expts on repellant action, see Expt 280[1].

439. **Oil of fennel**, for *corporis*.

Smeared on the body after a change of clothing it was found of no use in practice (Pinkus); men object strongly to the odour after a time (Meltzer). Recommended as a preventive by Bertarelli.

Expts 196–198: killed lice in 24 hrs by its vapour[1].

[1] See experiments with repellants, p. 488.

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440. **Oil of olives**, see p. 486 on the effect of greasy substances, also Nos. 451–2, 374, 377–8, etc., where it is used as a vehicle or adjunct.

441. **Oil of sassafras**, for *capitis*.

After combing and brushing out the obvious lice, dip brush in the oil and brush hair well. Plait and coil hair, apply close-fitting cap over all and retain it in place for 24 hrs. This kills all lice; comb out the nits. Recommended for institutional treatment and nurses approve of it. The oil costs about 3*s*. 6*d*. a pint, this being enough for 30 children. The smell is an objection (Raven). Allan recommends it but notes it soils pillows, etc. Shipley states that it is commonly used at the Hospital for Sick Children, Great Ormond Street, London, the oil being applied at night with a swab to the scalp and the hair being gathered into a butter muslin cap tied at the top of the head; in the morning the hair is well washed with soap and water[1].

442. **Oil of turpentine**, for *capitis* and *corporis* (Ol. terebinth. rect.).

Used since the seventeenth century for hospital pediculosis at Kolosvár. The pure oil does not irritate the skin or affect the kidneys, the smell is not unpleasant and it does not soil clothes. Marschalko has used it for many years for head-lice on women and children. It is cheap and not so inflammable as benzine. Application: spray or wet head with oil, bandage head with flannel cloth held in place by loosely applied muslin bandage and wear dressing overnight, the lice being dead in the morning (Marschalko). Nysten and also Renault recommend rubbing it on the hair, but give no further instructions; it is stated to kill head-lice rapidly.

Sprayed on the bodies of soldiers with satisfactory results in the trenches in Bukowina; it kills *corporis* (lice and nits) and does not irritate skin or soil clothing. No toxic effects follow its inhalation if there is good ventilation (Marschalko). It is also recommended by Nysten (1858) and Renault (1915). It may be applied on a cotton pledget or as an ointment; it is effective when impregnating underclothes but evaporates too fast for practical purposes. (Engelhardt.)

Expts 211–213: vapour killed lice in 24 hrs but nits were unaffected by 6 days' exposure. Expt 269: lice survived 6 hrs exposure to vapour near man's body. It doubtless acts chiefly by contact.

[1] See experiments with repellants, p. 488.

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443. **Paradichlorbenzol**, for *corporis*.

Preparation patented in Germany as "Globol," used in powder or worn in sachets containing 10 g. Recommended by Curschmann but discredited by other authors.

444. **Paraffin**, soft, added to insecticides renders clothing difficult to wash (Peacock, *MS.* 1918).

445. **Pepper**, black, for *corporis*.

It having been stated that pepper drives out all vermin when applied to clothes, Rabe tested it and found it useful and odourless. Curschmann states, as might be expected, that it burns when applied to the skin and consequently is unsuitable.

446. **Peru balsam** ointment, for *capitis* and *corporis*.

For *capitis*, apply as a pomade, strength 1 : 10 in vaseline, in cases where impetigo is present; wash the head afterwards with Panama wood decoction (Brumpt). A "specific for smell and suppuration" (Pinkus).

For *corporis*, several inunctions with it or "Perugen" were found useful especially where the body hair could not be shaved as in typhus cases (Brauer); also recommended by Meltzer and the Kais. Gesundheitsamt.

See also Nos. 452–3.

447. **Peru balsam** and **sulphur** ointment, for *capitis*.

The ointment (Peru balsam 4 g., precipitated sulphur 4 g., vaseline 20 g.) is suitable for children. Apply at night, wash with Panama wood decoction in the morning and repeat the process 2–3 times (Dubreuilh and Beille).

448. **Petrol**, for *corporis* and *pubis*.

For *corporis* it was tried as a spray on clothes but found ineffective (Orticoni). For *pubis* apply to all parts of the body; it gives instant relief and "appears to destroy lice and nits almost at once." Employed for years and found much better than shaving and mercurial ointment. Steep clothes in it if they cannot be disinfested in the usual way. The smell soon disappears (Bapty).

Expts 30–34: *corporis* nits survived exposure to vapour for 5 minutes and immersion therein for 10 minutes. Expt 353: *pubis* survived 5 minutes' exposure to vapour, immobilized in 1 minute and killed in 2 minutes when immersed therein.

449. **Petrol** and **methylated spirit** (1 : 2), for *capitis* on women and children.

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Treatment: (1) wash the head in the ordinary way, (2) rub vigorously with a rough towel until partly dry, (3) have the child shut the eyes tightly and stoop over basin with hair hanging over the forehead, (4) pour the fluid on the head and the lice will fall into the basin. Cheaper and as effective as xylol-ether, vide No. 474 (Allan).

450. **Petroleum**, for *capitis*, *corporis* and *pubis*.

Variously called *Paraffin oil* in Great Britain, *Kerosene* in the United States and Russia, *Petrole* in France, *Naphtha* in Poland.

For *capitis*, the Health Authorities, Boston, Mass., advise parents to procure 8 oz. of crude petroleum, to wet the hair thoroughly for 3 hrs, then to wash the whole head with warm water and soap, repeating the treatment on three successive days. Nits are removed with a fine comb with the aid of vinegar, the combing being repeated until all are removed (Greene). According to Paul the method is convenient as it "instantly" destroys lice (untrue), loosens nits and soothes cutaneous irritation (since it removes the offending lice no doubt, but it may of itself act as an irritant, v. infra). Application to the head by the bonnet method is advocated by Castellani and Chalmers, Ragg, and Filippini, the latter stating that this method has been used for soldiers in Italy; it is freely applied to the head, which is then enveloped in an air-tight covering for some hours, after which the head is washed with soap and water; the treatment should be repeated after 24 hrs. Both of these methods of applying petroleum are well known in different countries and are frequently applied in this country by parents of the poorer classes.

The objection to petroleum is its inflammability. Paul states that it may be set on fire by sparks from frictional electricity in champooing as explained by Lord Kelvin in connection with a series of accidents that occurred some years ago in London champooing establishments; to my recollection, however, these accidents followed upon the use of petrol. Champooing does not, however, constitute a part of the treatment for head-lice. The method is cheap and efficacious but the odour is disagreeable until removed by washing.

For *corporis* it is stated to be of some use when smeared along the seams of clothing (Meltzer) and it has been thus applied at the Suez Canal (Dore). It was used as a spray applied to the skin of soldiers in Serbia, after a bath, or rubbed on the skin with cloth or cotton

Ref. No.

wool; no bad effects and but little dermatitis[1] were observed (Castellani and Jackson). It was applied once a day with good results as a cure and preventive; when the skin became irritated the petroleum was mixed with an equal volume of vaseline and rubbed on gently with the hands; shaving all the body hair as a preliminary measure was found advisable (Barrie). Petroleum, applied to the body in conjunction with a weekly hot bath and complete change of underclothing was made compulsory on the border between the United States and Mexico because of typhus with the result that lice were practically eliminated (Cumming).

Petroleum quickly immobilizes lice, it does not kill them "almost instantly" as Castellani and Jackson assert. Boral notes the necessity of shaving the body and finds that petroleum does not kill the nits of *corporis* or *pubis*. Engelhardt objects to petroleum on the ground that it is too volatile, malodorous, and irritating to the skin[1], but believes that it repels lice.

For *pubis*, Bapty prefers petrol (see No. 448) as in his experience petroleum produces a burning sensation and may even cause the skin to peel off over the scrotum and about the fork[1]; it is necessary therefore to wipe away quickly any excess or bathe it off with soap and warm water. Petroleum can be applied to clothes that cannot be otherwise disinfested.

Expt 379: body-lice when immersed therein were killed in $1\frac{1}{2}$ minutes but nits survived 20 minutes. Expts 218–219: the vapour had no effect on nits in 15 minutes; lice were killed in 24 hrs. Expt 354: *pubis* when immersed were immobilized in 5 minutes and subsequently died; the vapour had no effect in 15 minutes.

See also No. 396.

451. **Petroleum** and **olive oil** (1 : 1), for *capitis* and *corporis*.

For *capitis*, it appears to have given general satisfaction. It is useful when many lice are present (Moniez). Dubreuilh and Beille state that it is usually employed for school children in France when parents are forced to de-louse them. The head is thoroughly oiled at night and covered with a bonnet, the hair being well washed next morning with soap and tepid water; this treatment is repeated on 2–3 consecutive nights and it destroys all the insects, nits being afterwards removed with vinegar and a fine comb. Brumpt recommends the same treatment but suggests the use of compresses to the head.

[1] The chemical composition of commercial petroleum varies and idiosyncrasy must be taken into account. G. H. F. N.

Ref. No.

Sobel, writing from experienee in New York sehools, states that after applying the usual remedies "with only fair, and often discouraging results" the Department of Health there advise the following proeedure (or No. 405 as an alternative) for sehool ehildren: Shake the mixture and apply it, wrap the head in a towel or rubber eap to cover all hair, after 6–8 hrs shampoo the head as follows: add 1 teaspoonful of sodium earbonate to 2 quarts of warm water, wet the hair therewith, apply Castille soap and rub the head well for 10 minutes, rinse out the soap with clear warm water, dry well; repeat this onee a week. Sobel omits to mention the use of vinegar for removing nits but direets that a eomb be used for the purpose or else sandpaper. Renault merely mentions that the mixture is to be rubbed on the hair, whilst Fasal gives fuller direetions ineluding the use of vinegar.

The method is recommended for use in the French Army (W.O. 1915), the soldiers' hair is eropped with elippers, anointed and rubbed with a eloth whieh is left overnight wrapped about the head.

Lelean also advocates the method (see pp. 566, 567).

The foregoing evidence proving the usefulness of the method comes from independent sources in different eountries and therefor earries weight.

452. **Petroleum**, **olive oil** and **Peru balsam**, for *capitis* and *corporis*.

These eonstituents are recommended in various proportions, 100 : 50 : 20 g. by Railliet, 100 : 50 : 10 g. by the Italian authorities (Bertarelli). Railliet prefers the mixture to either staveacre, blue ointment, pyrethrum or flowers of sulphur (the last two are useless by the way) for *capitis*. Bertarelli states that it has been reeommended for use in Italy against *capitis* and *corporis* since March 1915.

453. **Petroleum**, **Peru balsam** and **oil of Laurel**, for *pubis*.

Preseribed by Broeq (Dubreuilh and Beille).

454. **Petroleum-soap emulsion**, for *corporis*.

Dissolve 1 kilo of soap in 2 litres of very hot water, add 2 litres of petroleum followed by 2 litres more of hot water. Apply hot as a spray to floors or a dip for boots. Reeommended by Clere who had eharge of 500 enemy prisoners in a eamp in Serbia.

455. **Petroleum-soap-cresol-sulphur emulsion.**

This consists of soft soap 56 lbs., petroleum $2\frac{1}{2}$ gallons, eresol $\frac{1}{2}$ gallon, flowers of sulphur 1 lb. Mix and heat to ea. 100° C. whilst stirring well. Reeommended for use by soldiers when bathing (Moor and Cooper, 1918, pp. 92–6).

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455*a*. **Petroleum-soap-lysol emulsion**, for *corporis*.

Apply to wounded men after shower-bath, soaping them down with a brush. The mixture consists of petroleum 1 pt, soft soap 2 pts, lysol solution 1 pt. Afterwards apply 3 % cresol ointment to the hairy parts (Adler-Herzmark).

456. **Petroleum-vinegar** (1 : 1), for *capitis*.

Apply to women's hair covering it with a towel for half an hour. The acetic acid loosens the nits (see No. 364) which are combed out after the immobilized lice are washed away with warm water and soap containing petroleum.

Phenol, see No. 383.

457. "**Plagin**," a nostrum (powder) extensively sold in Germany soon after the war began. It was found to produce numerous small, circular or oval erosions on the skin with which it came in contact. The remedy produced itching followed by pimples which gave rise to the erosions 16 hrs after the application of the powder (Löhe). The nostrum was analyzed and the quackery exposed, the unscrupulous makers being presumably prosecuted (Priess). A number of soldiers were rendered unfit for service by it for a week (Demsar).

Proprietary Remedies and Nostrums, see remarks on under Nos. 286, 287, 307, 309, 324, 327, 328, 339–347, 360, 408, 457, 460, 473, etc.

458. **Pyrethrum**, for *capitis* and *corporis*.

Nearly all the evidence points to its being useless for lice, although it drives away fleas. I am informed that negro women in parts of South Africa employ it extensively on their hair, perhaps because they like the odour and they consider the yellow powder decorative as a correspondent informs me. Five different kinds of "insect powders," all highly recommended (they usually contain pyrethrum), were tested by Friedmann and found useless, the lice living for hours in dishes containing the powders. "Unless fresh it is of little value" writes Kinloch. It is recommended nevertheless by Lelean (1917), Kisskalt and Friedmann found it useless, and Peacock (*MS.* 1918) states that our soldiers all say it is valueless. Brunton cites Cantani (*Pharmacologia*, 2nd ed. II. 212) as recommending an ointment of pyrethrum and lard (1 : 2) as "most efficacious"; perhaps its efficacy depended solely on the lard!

Expts 73–74: lice survived for days in a box with the powder; Expts 221 and 270 also point to it being useless. See experiments with repellants, p. 488.

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459. **Quassia** infusion and oil, for *capitis*.

I have seen this applied in practice but there is no evidence that the oil alone would not be equally efficacious. The infusion does not prevent lice from biting (see p. 490).

460. **Sabadilla** (Cevadilla), for *capitis*.

According to the *Dispensary of U. S. America*, 19th ed., 1907, the dried ripe seeds of *Asagroea officinalis* (Cham. and Schlecht) Lindl., recognized in *Brit. Pharm.* of 1885, contain three alkaloids: veratrine, cevadine and cevadilline. Sabadilla, known in Europe since 1752, was formerly used as a taenicide; it is the chief constituent of *pulvis capucinorum* still sometimes used in Europe for the destruction of head-lice. Veratrine ointment (2 %) has been used in rheumatism; the alkaloid is very toxic. Dr Andrew Balfour informs me that 258 tons of sabadilla seed were imported into Germany from Venezuela in 1913, doubtless from foresight in connection with the contemplated war.

Sabadilla vinegar is one of the remedies recommended in a circular issued by the Kais. Gesundheitsamt early in 1915 (Editorial, 12. VI. 15) and it is advised by Klemperer and Zinn. Postnikov, in a list of remedies for *capitis* and *pubis,* includes alcoholic extract of sabadilla. Pinkus notes that sabadilla vinegar may produce itching and a painful exanthem.

"*Harrison's Reliable Nursery Pomade.*" In the *Pharmaceutical Journal*, 5 Oct. 1907, pp. 444–445, in the Case of the Pharmaceutical Society *versus* Randall, tried at Bow County Court, the defendant was fined £5 and costs in respect of the sale of a poison, he being an unqualified person. It was stated that the pomade was considerably used in some parts of London, that the contents of a sample box, duly analyzed, was found to contain a poisonous vegetable alkaloid, veratrine, to the amount of $1\frac{2}{3}$ grains, $\frac{1}{8}$ of which would be "an exceedingly dangerous quantity" in the event of anybody taking the substance.

From information that has reached me from two sources it would appear that the amount of veratrine in the pomade varies (between $\frac{1}{2}$ and 1 % ?). A tin purchased in Cambridge, 7. III. 1918, is inscribed "Harrison's 'Reliable' Nursery Pomade. A Certain Cure for Nits and Vermin in the Hair. Price $4\frac{1}{2}d.$ and 9*d.* To be rubbed into the Scalp daily. Not to be applied where the skin is broken. This pomade is now labelled poison but is quite harmless in use." The covering box bears the assertions that it is a "hair colour restorer (not a dye)" and "adds to the beauty and growth" being "the surest Hair Producer yet invented," etc. "In bottles 1*s.* 6*d.*"

Expt 222: vapour of alcoholic extract of sabadilla had no effect on lice when exposed thereto for some days. Sabadilla doubtless acts by

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contact only. Expt 282: sabadilla vinegar and balsam of Peru exerted but slight insecticidal effect when tested on man. Expt 355: sabadilla vinegar did not kill *pubis* immersed therein for 5 minutes. Expts 305, 308, 310: ½ % veratrine in vaseline applied to flannel with lice upon it and worn near the body killed the insects slowly and acted for a long period (not volatile like naphthaline). Expts 307, 309: with Harrison's pomade gave similar results to the foregoing.

461. **Soap**, soft, for *corporis*.

Black soap is recommended for lice in James's *Med. Dict.* (1743, *loc. cit.*).

Soft soap constitutes a valuable addition to naphthaline (Bacot and Copeman, see No. 429 (*g*)). It is commonly employed combined with carbolic acid, cresol, lysol, petroleum, etc. Care should be taken that it does not contain too much free alkali when it is used for application to the skin. Hönck recommends it against lice, it being applied to the body after the shower-bath and then rinsed off; he treated 15 soldiers at a time in this way or 200 per day, the men resting on straw in a heated room till their clothes were returned dry and shaken from the steam disinfector.

462. **Soda solution**, strong, for *pubis*.

Recommended by Linacre[1] (Bryant, 1838).

463. **Staveacre**, for *capitis*, *corporis* and *pubis*.

Staveacre or louse-bane[2] is an ancient remedy for head-lice; it is mentioned by Pliny (1st century) in the *Book of Quinte Essence* (1460–70), by Sennertus (1572–1637), and others, as will be seen by reference to p. 516. It is recommended by some modern writers as an ointment or concentrated decoction for *capitis* and *pubis* (Nysten, 1858; Girard, 1885) or for *corporis* when added to oil (Frazer, 1885).

Unguentum staphisagriae (staveacre ointment) is an old remedy prepared as follows according to *Brit. Pharm.*, 1914: staveacre seeds 20 g. are crushed and digested with benzoated lard (85 g.)[3]

[1] Linacre died in 1524.

[2] The dried ripe seeds of *Delphinium staphisagria* L., having no marked odour; taste nauseous, acrid.

[3] Benzoated lard consists of prepared lard 1000 g., benzoin in coarse powder 30 g. Melt the lard at 60° C., stir in benzoin, strain and stir till cold. (Benzoin is a resinous solidified balsam from the incised stem of *Styrax benzoin* Dryand., the "Sumatra benzoin" of Commerce. *Brit. Pharm.*) Styrax or storax is an old louse remedy, vide Gilbert's prescription (ca. 1510), p. 516.

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in a water bath for 2 hrs, strained, and yellow beeswax (10 g.) added.

Oleum staphisagriae dil. 1 pt and olive or almond oil 6–12 pts with perfume (some aromatic oil, q.s.) is recommended by Frazer for *capitis*. Apply to the head in the ordinary way; one liberal application kills the lice. Repeat treatment in 7–10 days to destroy the larvae that may hatch out of the unaffected nits from the first treatment. Frazer recommends its occasional use as a prophylactic. An old remedy, stated to be also efficacious for *corporis*. Judging from Expts 224, 356, staveacre acts by contact only; the decoction killed *pubis* immersed therein for 5 minutes.

Styrax, for lice, see footnote [3] on previous page.

464. **Sulphur**, for *corporis* and *pubis*.

For *corporis*, according to information supplied (9. IX. 1915) by Colonel W. H. Horrocks, C.B., and Major P. S. Lelean, R.A.M.C., it was tried on a large scale at the British front in France. "Far from doing any good it was reported that it only seemed to make the vermin more active." Sulphur was therefore struck off the list of remedies employed in the army.

Precipitated sulphur was recommended in Germany by Eysell as a prophylactic, 2 tablespoonfuls being dusted inside the shirt and its sleeves, and inside the drawers, the effect being stated to last for weeks and no injury to the skin being produced. When a man has worn sulphured clothes 24 hrs and has sweated, H_2S is evolved and is supposed to kill the lice. Eysell points out that *flowers of sulphur should not be used* because the crystals irritate the skin contrary to the precipitate which is an amorphous powder. Shipley cites various persons as recommending flowers of sulphur dusted into the clothes, and taken internally, whereby H_2S is given off from the skin so that silver is blackened in the pockets (Harman). Dr H. H. Tomkins of Liverpool (ca. 1885) is quoted as stating that sulphur rubbed in the underclothes of patients wearing plaster of Paris jackets and tormented by lice beneath the jackets, gave results that proved an "absolute success." Lounsbury reported the use of sulphur bags worn by troops in S. Africa. Pouillaud also recommends sulphur.

Hot sulphur baths are mentioned by Nysten (1858) as a slow means of ridding the person of lice, especially in the case of *pubis*. (Expts 95–96 are not convincing.)

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N.B. Sulphur powder, applied as recommended by Eysell, was tried during sultry weather by Neumayer who states that he sweated freely and hoped that the H_2S evolved would keep off lice. Some days later he suffered from diarrhoea, severe cramps and collapse attributed by him to H_2S poisoning. Silver in his pocket turned black. See also Nos. 430, 447. Beware of producing *sulphur dermatitis*.

465. **Sulphur dioxide** (SO_2) fumigation, for *corporis*.

Opinions as to the value of sulphur dioxide fumigation for the destruction of lice differ widely. It has been found untrustworthy by Fränkel, Furno, Swellengrebel, Busson and others on the ground that nits frequently survive or that when fumigation has to be applied to larger spaces it is difficult or impossible to attain or maintain the requisite lethal concentration of SO_2 in the chamber. Sulphur fumigation has been practised from ancient times, but by bacteriologists it is very generally regarded as inefficient. Its use however in combating yellow fever has been justified in so far as it affords a useful means of destroying the mosquito that conveys the disease. Whereas it readily destroys lice in the active stages it does not give satisfactory results with nits as far as recorded observations go (v. infra). Favourable opinions as to its use are expressed by Nysten (1858) and many writers since. In the French army, early in 1915, sulphur was chiefly used for disinfestation, steam being much less employed. The method has been in use in all the armies engaged in the present war, this not affording proof in my opinion that the method is efficient. Any method of disinfestation that falls short of destroying the more resistant nits must be regarded as merely palliative. The following are the objections to the use of sulphur for the purpose of killing lice.

Inefficiency. In my opinion a false impression has arisen because the active stages of lice are found dead in large numbers among effects treated by SO_2. The recorded evidence regarding *nits* (see Expts 225–233, 248–249) is, however, as follows:

SO_2 vols. %	Acting for	Result	Authority
2	2 hrs	all killed	Nocht and Halberkann
2·5	7 ,,	1 nit survived	Bacot and Gair
3·1	7 ,,	2 nits survived	,,
Kilos of S. burnt per 100 cbm.			
1·6	18 ,,	mostly survived	Swellengrebel
2·6	18 ,,	some survived	,,
3·2	18 ,,	mostly survived	,,

I can find no other trustworthy records on the subject. Bacot and Gair's experiments were carried out with accuracy under practical working conditions in a disinfestation hut, gas samples being periodically removed by Gair from the chamber and analyzed, the Clayton apparatus functioning continuously during the whole exposure period. Usually the percentage of SO_2 is estimated from the amount of S burnt per cubic space, according to statements commonly contained in text-books, but this procedure is fallacious in view of the occurrence of leakage of gas from the chamber, and the great amount of SO_2 that may combine with the clothing exposed. Gair found, when working with a Clayton apparatus, that it was most difficult to *maintain* the SO_2 % in the chamber at anything like uniformity, this in spite of the continuous supply which is absent when ordinary fumigation methods are employed.

Injurious effects. When the clothes are damp they are injured by the process. SO_2 dissolves in water, sulphurous acid is formed and the latter attacks the fabrics. Sulphurous acid bleaches either by abstracting the oxygen from the colouring matter or by forming compounds with dyestuffs. Like other acids it injures wool, causes clothing to lose its wearing qualities, and tarnishes metal. When dry clothing and dry gas are employed the fabrics are stated to suffer no injury, but if soldiers put on recently treated clothes and go out into the damp or wet, sulphurous acid is formed and promptly exerts its injurious effect. Even when inhaled in small quantity SO_2 may produce bad symptoms in man. According to Haldane, about 6 % of the S consumed forms SO_3 giving H_2SO_4 with water.

Long exposure required and smell retained in clothing. The length of exposure in the fumigation chamber under practical working conditions is given as 3 hrs (with 3 vols. %, Nocht and Halberkann), 3 hrs (followed by 2 hrs airing before the clothes can be worn; Galewsky's experience with a Walther apparatus applied to Russian prisoners' effects at Königsbrück), 4 hrs (Heymann), 8 hrs (with Clayton apparatus running continuously to maintain the SO_2 at 3 %, Gair), 9 hrs (Adler-Herzmark, using a Grassberger apparatus), 12 hrs (Kuhn, burning sulphur in the chamber); refer also to the table preceding the two foregoing paragraphs. The smell emanating from treated clothing may persist for a week or more; this may be an advantage, however, assuming that it repels lice as has been asserted.

Cost. Peacock (see p. 477) estimates the cost at 5 times that of disinfestation by hot air or steam and the cost of sulphur has since risen.

Waste. In cold weather, the greater part of the SO_2 is lost as an insecticide because it combines with the fabrics that are treated; a variable amount is lost by leakage out of the chamber; a certain amount of sulphur is sublimed; these portions having no effect on lice (Captain C. J. D. Gair, *MS. Report*, W.O. III. 1917).

Captain Gair (*MS. loc. cit*) reports of his experimental hut supplied with a Clayton apparatus, stating that it was capable of dealing with 3500 blankets at a time except in cold weather (0–7° C.) when the output was reduced 50 % owing to the great absorption of SO_2 by the blankets. Three Clayton machines supplying SO_2 to the hut (floor area 60×20 ft.) took 3–5 hrs to bring the SO_2 up to 3 %. The amount of sulphur burnt for each load was 130 lbs. It took $3\frac{1}{2}$ hrs to pack the hut, 8 hrs is reckoned as an adequate exposure period and $\frac{1}{4}$ hr for subsequent ventilation prior to removing the contents. The personnel required is 12 men for 1 shift or 24 men if 2 shifts are required.

Lieut. Peacock (*MS.* I. 1918) tested lice and nits in a disinfestation hut of ca. 2700 cu. ft. capacity ($24 \times 14 \times 8\frac{1}{2}$ ft. (high)) using a motor driven Clayton machine type "M." Under the best conditions it took 9 hrs to deal with 350 blankets, the cost of sulphur, spirit and oil used being reckoned at 12*s*. The SO_2 produced ranged from 2 to 4 % (maximum). It took 3 hrs to reach 3 % and 35 lbs. of sulphur were consumed of which he estimates that $19\frac{3}{4}$ lbs. were wasted, some 50 % of the SO_2 being absorbed by the blankets alone and consequently exerting no insecticidal action. Peacock notes the difficulty of standardizing the method because of variations due to (*a*) the character of the individual huts, (*b*) outside conditions, (*c*) personnel, (*d*) blankets, etc., that are subjected to treatment.

It appears to my unbiassed judgment that *the foregoing evidence sufficiently condemns* SO_2 *as a means of destroying lice.* It is shown that it is untrustworthy, injurious to uniforms, slow in action, unduly costly and wasteful. The slowness of the process makes it impossible for the soldier to resume his clothing promptly after a bath as in the case of hot-air or steam disinfestation. The soldier must either wait around for hours or be supplied with a completely fresh kit.

After expressing the foregoing views it seems scarcely worth while to dwell on the methods of sulphur fumigation employed, but a short statement is nevertheless appended:

The old familiar method of mixing sulphur with charcoal and igniting it with alcohol can be employed in sealed rooms (in which effects are suspended on wires as used in France); ordinarily not much more than 20 % of the sulphur is consumed. Busson describes how 300–400 litre petroleum barrels have been used for fumigation by removing the bottoms and replacing them

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with wooden grids, the barrels being placed over a closed-in pit in which sulphur is burnt beneath the effects in the barrels, an hour's exposure being deemed sufficient to kill lice. Professor Mary of Paris informed me in August 1915, that SO_2 led into barrels had been used in the French army since Oct. 1914, it having been found that the gas killed lice and nits; it gave satisfactory results after being used on a large scale in conjunction with baths. In Germany, the Grassberger apparatus has been much employed; here stick sulphur is broken up and placed with methylated spirit in iron gutters covered by guards; when ignited, a considerable degree of heat may be produced which would help in killing lice; the Walther apparatus is also recommended as being simpler, it burns 4·5 kilos of sulphur per 100 cbm. space. The Clayton apparatus has been much used in the British army; here the sulphur is burnt in a furnace in a draught of air induced by a pump, the cooled gases entering the chamber and the air in the latter being drawn out and pumped in again until the atmosphere within the chamber contains the desired SO_2 % (3 % being usually regarded as sufficient when acting for 2–3 hrs). Galaine and Houlbert describe an apparatus which automatically diffuses the gas issuing from a steel receptacle containing liquid SO_2, the gas passing to the chamber through a spiral tube traversing a water boiler. Steel cylinders with liquid SO_2 have long been used for disinfection, 9 kilos of SO_2 being reckoned per 100 cbm. space[1].

According to Kisskalt and Friedmann, *burning carbon bisulphide* gives much better results with lice than when sulphur is burnt; it is also stated to be cheaper. For this purpose the authors, Nocht and Halberkann, and also Mense, recommend that a mixture of CS_2 90 %, methylated spirit 5 %, and water 5 % be used, 2·5 kilos of the mixture being reckoned per 100 cbm. and the exposure lasting 6 hrs. This mixture is stated by Mense to be equally good and much cheaper than a commercial preparation called "Salfarkose" sold in Hamburg and recommended by some authors; this preparation consists of CS_2 90 %, with water, alcohol, formalin and mustard oil together 10 %. (See No. 384 regarding dangers, etc.)

466. **Tar preparations**, for *corporis*.

Crude birch-tar (5 %) in water is recommended for the impregnation of underclothes; these become slightly stained and are stated to repel lice afterwards for 10–15 days (Engelhardt); it is also recommended for impregnating bandages (Swoboda). Black birch-tar (10 %) in alkaline water is recommended for steeping underwear, Russian observers believing that clothes thus treated keep away vermin (Marzinowsky, Popov). Crude birch-tar (1 %) in 50 % petroleum emulsion is stated to kill lice and render clothing odorous for a long time (Engelhardt). Crude tar oil 4 oz. per 2 lbs. of soft paraffin is recommended as an ointment by Peacock to be

[1] Those interested in SO_2 fumigation should consult *Notes for Sanitary Officers*, B.E.F., France, 1917, pp. 46–56.

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applied every 3–7 days; it is a better "killer and deterrent" than Vermijelli (see No. 473) and is applied in the same way. It does not kill *nits*.

Expts 337–338: are insufficient to prove the efficacy of crude tar oil with or without soap or soft paraffin, but they indicate that it kills lice and apparently causes them to migrate for the insects wandered from treated to untreated parts of the clothing. The range of the effect is limited as with naphthaline. It is easy to apply in the trenches and appears to exert an effect for 3–4 days. Further tests with tar preparations should evidently be made[1].

467. **Tetrachlorethane**, for *capitis*.

Recommended by Kinloch for application with a cotton plug to the head. There is no evidence that the author has actually applied it in practice.

468. **Tobacco**, for *capitis*, *corporis* and *pubis*.

For *pubis*, tobacco infusion has been applied, but Bryant (1838) records the case of a youth he knew who nearly killed himself by applying a strong infusion to the pubic region. Nysten (1858) prescribes 60 g. per litre of water.

For *capitis* and *corporis* an infusion was already recommended as an insecticide by Löwenhardt (1840). For *corporis* a strong infusion or decoction is advised by Girard (to be lightly applied) and Comstock. Prowazek and other German writers advise using an infusion wherein a cigar is steeped in a litre of water. It is well to bear in mind that tobacco thus applied to the skin is dangerous unless used moderately.

Swoboda recommends scattering *tobacco dust* on the bandages of wounded soldiers. *Tobacco smoke* issuing from a pipe was used by Jousseaume whilst travelling in the Red Sea; he fumigated his underclothes repeatedly with good results for the following 24 hrs. As a makeshift method for temporarily alleviating the annoyance due to the presence of lice this method appears worth noting. See No. 472, last §.

Expt 236: tobacco smoke is stated to have killed lice in 15 minutes; it appears more probable that they were merely stupefied; the effect on nits is nil[1].

469. **Toluol** for use against lice has been suggested, but there is no evidence as to its usefulness.

[1] See under experiments with repellants, p. 488.

Ref. No.

470. **Trichloraethylene**, for *corporis* in clothing.

Ragg's directions are: turn the clothes inside out; lay them in layers in an air-tight box, spraying each layer as it is laid in; close the box overnight. On the next day air the clothes 1–2 hrs, brush and beat them. Metal buttons are not tarnished. The fluid is not inflammable (boils at 88° C.). Use 3–4·5 kilos per cbm. space.

Expt 237: the vapour is stated to kill lice in 30 minutes; no evidence as to nits.

471. **Tricresol** powder (3 %), for *corporis*.

Recommended by Herxheimer and Nathan. Expt 238: the vapour had no effect on lice in 1 hr. Expt 283: dusted on heavily infested men it had no visible effect after 24 hrs.

Trioxymethylene, see No. 370, last § but one.

472. **Turpentine**, for *pubis*.

For *pubis*: use a turpentine lotion (Nysten). A bath containing turpentine and tobacco infusion is recommended by Whiting (Bryant, 1838).

Vaseline is frequently used as a vehicle for various insecticides.

Veratrine, see Sabadilla.

473. **Vermijelli**, for *corporis*.

A proprietary remedy recommended by Lefroy who is responsible for the statement that it consists of Bottom oil (cracking point 600° C.) 20 pts, Texas fuel oil (sp. gr. 0·86; boiling point 200–350° C.) 50 pts, pure soft soap 30 pts, water (about) 6 pts. (1) Used as a prophylactic: smear the skin and hair, inside of stockings, socks, boots or puttees and along seams of clothing, at neck and wrists. It can be used as a soap when bathing and a little may be rubbed on the skin afterwards. (2) To destroy lice on infested persons: apply as before, and dust the body and inside of underclothes with N.C.I. powder (see No. 428). Lefroy moreover states that vermijelli emulsion kills lice when used for washing infested clothing and that the latter, on being wrung out and dried, protects against reinfestation. Vermijelli is stated to be non-inflammable and non-toxic. On the grounds of Lefroy's statements it was recommended in a War Office leaflet that $\frac{2}{3}$ oz. be rubbed into the seams of the coat and trousers of soldiers and used in conjunction with N.C.I. powder. Lelean recommends that 1 oz. be applied once weekly per man. Peacock states that it is very effective (Expt 97: only

Ref. No.

"fairly efficient") and is best applied as an ointment rubbed on the body from the head to the knees every 3–7 days.

Expts 92, 287: lice in contact therewith on impregnated cloth worn on man were unaffected by 9, or $6\frac{1}{2}$–$10\frac{1}{2}$ hrs exposure. Expt 272: when exposed to vapour under otherwise similar conditions they mostly survived 9 hrs exposure. Expt 328: exposed to the vapour it was only after 12 hrs that 15 % were killed, there being possibly some contact action as well. Expt 360: *pubis* immersed in 2 % watery solution was killed in 5 minutes. The experimental evidence does not bear out Lefroy's assertions regarding this article; he has however defended his standpoint (vide p. 90 of discussion following Bacot, IV. 1917) on the ground that experience in the field has justified his claims as to its efficiency. We leave it to time to decide the matter.

Vinegar, see Acetic acid.

474. **Xylol**, for *capitis*, *corporis* and *pubis*.

For *capitis* it is recommended as a head lotion by Borne when few insects are present; the treatment, repeated every few days, is followed by soaping and washing. Castellani and Chalmers advise merely dabbing it on which scarcely seems to me sufficient. Heusner's recommendations are better: Bind a strip of parchment paper, 10–15 cm. wide, around the head with a bandage; place a layer of wadding inside and close up to the paper; sprinkle the wadding with xylol, and cover it with a disc of cardboard previously cut to shape; place a bandage over all; where the hair is thick spray the wadding 2–3 times with xylol. Renault prescribes xylol-vaseline (30 g. containing 90 drops of xylol) to be rubbed on the hair. Xylol-alcohol (1 : 1) gives good results but irritates the skin and cannot be used where excoriations are present (Lagane). Xylol and ether (1 : 1) or xylol-ether and alcohol (1 : 2) are recommended for head-lice by Allan to be applied as described under No. 449, the latter prescription being preferred as equally good and cheaper.

For *corporis* xylol-vaseline (2 drops to 1 g.) may be applied to the body with benefit as Prof. Mary informed me in Aug. 1915, or spray xylol upon the clothing, where Heusner states it "kills almost at once" (untrue, the insects merely being immobilized). It is useless when dropped on clothing that is in use (Kisskalt). Rapeseed oil containing 5 % xylol is advocated by Arning (cit. Prowazek).

For *pubis*: recommended as a spray by Heusner (it immobilizes the insects quickly which facilitates their removal).

Expts 48–52: nits survive 10 minutes' immersion. Expt 80: nits survive 15 minutes moistened therewith. Expt 239: nits resist vapour for 3 hrs. Expt 363: *pubis* killed by $1\frac{1}{2}$–3 minutes' immersion, not less.

The objections to xylol are its great *inflammability*, that it may produce considerable itching, and a painful exanthem (Pinkus): it is moreover very expensive at present.

Index to authors' publications cited in the foregoing pp. 519 et seq., excepting a few cited in the text. For full titles of papers see Bibliography, pp. 1–42, 482–486.

1915, p. 70 (rev.)—Pouillaud, 1915, p. 56—Prowazek, 1915, p. 67—Rabe, 1915, p. 347—Ragg, 1915, p. 172—Railliet, 1895, p. 825—Raven, 1917, p. 64—Renault, 1915, p. 206 (rev.)—Shevirev, 1914, p. 5—Shipley, 1915, p. 395; 1916, pp. 17, 19, 28, 29, 31, 33—Sobel, 1913, p. 656—Soulima and Ebert, 1915, p. 340—Swellengrebel, 1916 *a*, p. 7—Swoboda, 1915, p. 836—Uhlenhuth and Olbrich, 1915, p. 776—Van Ooteghem, 1836, p. 75 (see bibliogr.)—Wesenberg, 1915, p. 861—Whitfield, 1912, p. 1648 (refers to his *Handbook on Skin Dis.* published 1907)—Widmann, 18. VIII. 1915, p. 292—Ziamal, 1856 (see bibliogr.)—Zucker, 1915, p. 294.

IV. PLAN OF DISINFESTATION ESTABLISHMENTS AND MODES OF PROCEDURE.

> "One learnt early that effective delousing of a unit is one of the most troublesome duties that a medical officer can undertake ; it is not that it is usually difficult itself, but it needs a thoroughness and devotion to detail, and endless trouble to secure the cooperation of combatant and other officers which many a beginner does not realize, and from which many an old hand recoils. But the work is well worth doing...."—Buchanan (1917, p. 22).

Both the plan of a disinfestation station and the mode of procedure adopted must necessarily depend on the facilities that are available in a locality and the circumstances that surround the men requiring treatment. This applies equally to soldiers, prisoners of war, and civilians. We shall confine ourselves chiefly to soldiers.

Soldiers may be: (*a*) Stationed at or near a place where everything required is at hand and where a complete disinfestation plant can be established in conjunction with baths and laundry facilities. (*b*) The foregoing conditions may hold but laundry facilities may be lacking[1]. (*c*) Soldiers may be in a position of being able to undress, change their underclothes and bathe, no disinfestation station being available. (*d*) They may only have opportunities of undressing and occasionally washing. (*e*) They may have no opportunities of undressing and keeping themselves clean through being kept continually engaged or on the move; prisoners of war, as in the notorious case at Wittenberg, may be similarly placed. The difficulties of dealing with the louse problem grow by leaps and bounds as we depart from the ideal (*a*) and approach the last condition (*e*) above described, and measures must be adapted to all shades of intermediate circumstances.

It is best to begin by considering the manner of solving the problem under favourable conditions and outlining a scheme for a complete

[1] See the instance described on p. 568.

station suitable for dealing with large bodies of men and their effects. Such a scheme incorporates various desirable features but it will necessarily have to be modified according to circumstances. I have sought to represent the general arrangement of a station by the accompanying diagram (Fig. 26), in place of a plan, because it is essential to lay down the *general principle* of the arrangements required. For the rest it will be necessary to find ways and means of utilizing to the best advantage what is available for the purpose under war conditions, the size of the station, the building materials, and all else varying greatly.

Various plans of such stations have been published: Uhlenhuth and Olbrich (1915, p. 776) give an excellent one based on a school building that was adapted for the purpose; this plan is the best that has appeared to my knowledge. Adler-Herzmark (1915, p. 258) describes briefly a station in connection with an infectious diseases hospital. Peacock (1916, p. 58) illustrates a simple plan of a station where the clothing is disinfested by ironing. Jacobs (1918, p. 237) gives a sketch plan of a suggested station provided with a hot-air disinfestor, but his plan is far from satisfactory although containing some features worth noting. Captain Harold Orr, C.A.M.C. (*MS.* iv. 1918), has sent me a sketch plan of a simple station that has been in use in France.

The diagram (Fig. 26) is arranged for the purpose of outlining a scheme for the treatment of (*a*) successive bodies of soldiers, (*b*) persons who straggle into the station, at irregular periods, (*c*) wounded, sick and others prior to their admission to the wards of hospitals or like institutions; (*d*) the scheme is adaptable to prisoners' camps, etc. With the aid of the diagram we may proceed to describe the plan of a station in conjunction with the successive stages required in the treatment of verminous persons, assuming that they are soldiers arriving at stated intervals in groups of say 20–100 or more.

Following a fundamental principle, the station is divided into two parts, the unclean and the clean side, these being separated outside the buildings by a high fence or wall as shown in the diagram.

Unclean Side.

(1) *The entrance* leads into a *waiting room* (or shed) where the men entering the station are protected against the weather. As they enter they pass

(2) *The personal property and ticket office* which is provided with a counter (represented by broken lines) over which they hand in their belongings and valuables, receiving a numbered metal disc in exchange.

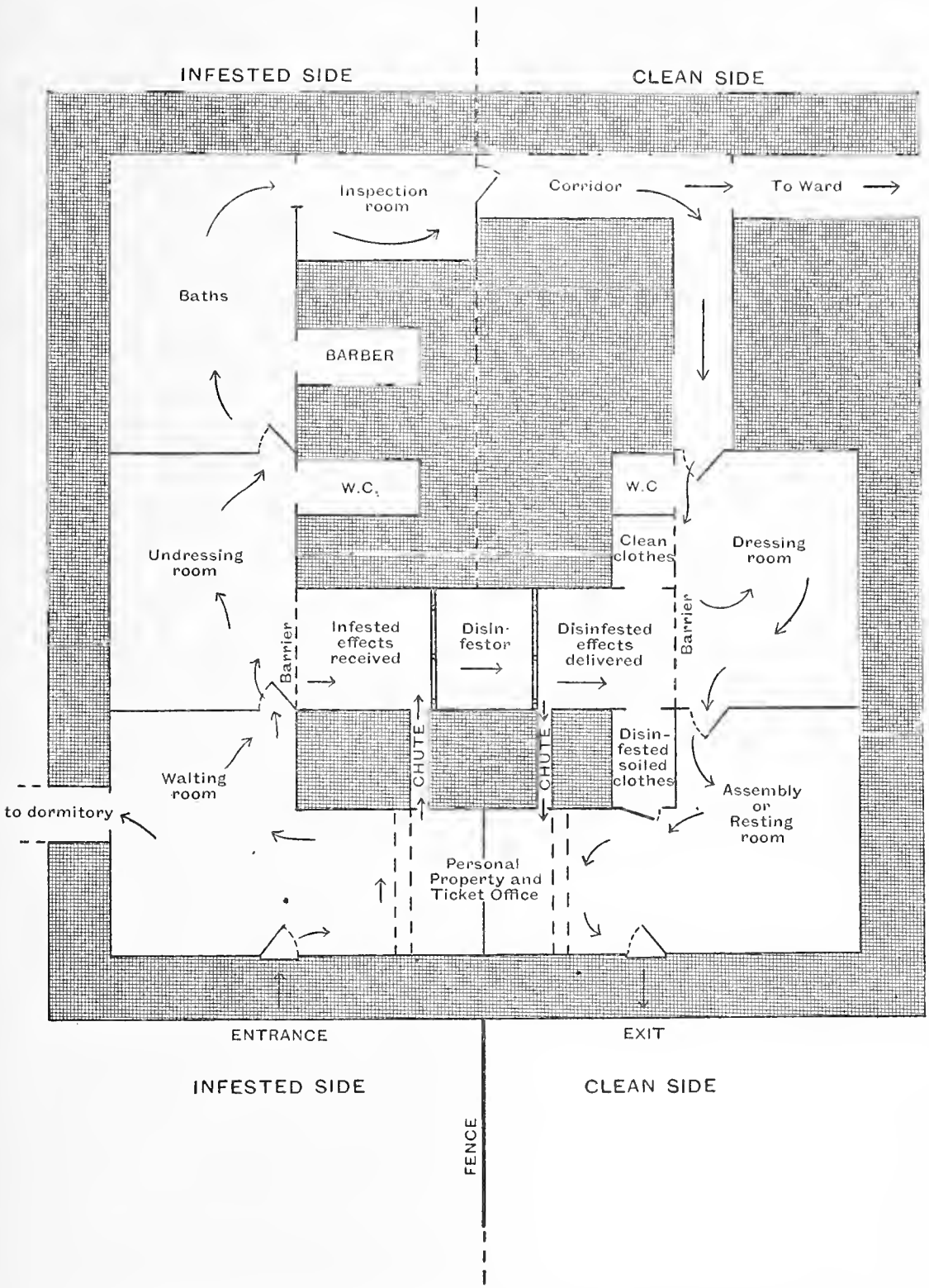

Fig. 26. Diagram of Disinfestation Station to serve as a guide to the general plan and mode of procedure employed in such establishments as described in the text.

Among a soldier's personal belongings are various objects which may have to be sorted into two classes at or before entering: (*a*) clean objects, and (*b*) infested or possibly infested articles; these objects (*a* and *b*) are placed in boxes or bags and numbered in accordance with the disc handed to the soldier. The clean objects (*a*) may be subsequently passed through a partition to the clean side of the office for delivery to the soldier when he leaves the station.

The unclean objects (*b*) may include the soldier's pocket book, scapulary (if Roman Catholic), identification disc (the string at times infested), amulets (a great variety of these are worn and may consist of cloth, hair, wool, etc.) and, most important, underwear which is the soldier's personal property. These unclean objects require to be disinfested although the men may be loth to part with them, largely from fear that they may be lost; the receipt discs, handed to them at the office, should serve to quiet their apprehensions. The objects may be loaded into special wire cages, locked if need be, which are run down a small inclined chute to the compartment adjoining the disinfestor on the unclean side.

Having relieved themselves of their personal belongings and received their numbered discs the men proceed to

(3) *The undressing room.* This is provided with benches running across the room, the seats being numbered in accordance with the men's discs. A *W.C.* is annexed to this room. The clothes, especially when heavily infested, should be handled as little as possible, because lice are liable to drop from them; they may be tied in bundles or placed in bags by the men for transfer to the disinfestor. The men hand all their effects in over a counter to the personnel having charge of the disinfestor, or they hang them on numbered racks whence they are subsequently removed by the attendants. In most stations it is not deemed necessary to disinfest the boots, but since heavily infested men may scatter lice about when undressing, it must be borne in mind that the insects may fall into the boots and consequently reinfest the men later[1]. It may be necessary to have a large table in the room upon which to sort and handle the clothing. Soiled underclothes, especially when heavily infested, may be dropped directly into tubs which stand in the room and contain insecticidal solution, or they may be passed over the counter

[1] The directions given by Peacock, and Jacobs, are for the men to place their boots in numbered pigeon holes, dropping their discs and "other belongings" inside the boots which are taken around to the clean side after the bath. This is not a desirable procedure where men are heavily infested, and "other belongings" is a vague term.

as separate bundles with the other clothes. Having left their effects with the personnel, who see that they are numbered, the naked men proceed to

(4) *The bathroom.* This is usually provided with shower-baths arranged in rows running across the room. Collective bath tubs or soaking vats are often employed before the men proceed to soap themselves, a portion of soft soap (ca. 1 oz.) being handed to each man. After lathering themselves well the men seek the showers, and, being provided with a clean towel, dry themselves. The used towel should not be taken from the bathroom; it should be dropped into a receptacle, or vat containing insecticide solution, for lice may remain clinging to towels.

Opening as an annex into the bathroom is a *barber's establishment*, to which the men may have to resort before or after the bath. Whilst ordinary hair-cutting will usually have been performed by regimental barbers outside the station, hair-cutting or shaving may have at times to be practised at the station, especially when men are found with lice and their nits (*Pediculus* or *Phthirus*) upon their heads or bodies.

Before leaving the bathroom the men should dip their feet in tubs containing insecticide solution to remove any lice that may have adhered to them by walking on the floor upon which lice were possibly shed by the bathers. The men now proceed to the

(5) *Inspection room*, where they are carefully examined all over in a *good light* for lice and their nits (or for that matter for scabies). If still infested, the men are sent back to the bathroom or barber's shop as required. If found clean, they now leave the unclean side of the station by passing along the

(6) *Corridor* leading to the dressing room. The floor of the passage may be covered with closely woven matting soaked with insecticide solution, whereby any stray lice, possibly carried on the feet, may be disposed of. The men now enter the

Clean Side.

(7) *Dressing room*, where they receive (*a*) clean underclothes, and (*b*) their numbered garments that have in the interim passed through the disinfestor. The clothing is handed to them over counters, and the room is provided with numbered cross benches like those in the undressing room. A *W.C.* is annexed to the dressing room. The men then pass to the

(8) *Assembly or resting room* (or shed), and (9) *Office* where they receive their personal belongings (*a* and *b*, vide Step 2), such of these (*b*) as have had to be disinfested having passed through the disinfestor and

been returned to the clean side of the office through the return chute. The men, when assembled, now leave the building by the exit door on the clean side.

Where a station has to deal with *men straggling in at irregular intervals*, provision must be made for their accommodation pending the time when it will be convenient to treat them and their effects. This eventuality is considered in the diagram (Fig. 26) wherein is shown a passage leading from the waiting room on the unclean side to a room marked *dormitory*. Such a room is also necessary in conjunction with any hospital or other institution (poor house infirmary, etc.) that is liable to receive verminous inmates at odd times or persons that have to be provisionally isolated.

Where a station has to deal with *wounded, sick, or indigent poor*, the diagram shows the procedure that should be followed before they are admitted to the wards. In small institutions, the various apartments (assuming that the diagram were the plan of a building) must be taken as merely representing *stages* in the process of ridding the newcomers of vermin. Wounded soldiers would be received in the waiting room or rooms provided with stretchers or seats, and, after being classified, would be passed on to the undressing room and thence to the bathroom, both being provided with suitable requisites. The patient passes thence to the operating room or ward. In many cases, naturally, the complete lousing of the wounded and sick cannot be carried out, and makeshift methods are all that can be applied, due precautions being taken that the patients shall not spread lice by accommodating them, when practicable, in special quarters.

General matters relating to the plan of lousing stations. It is desirable, when possible, (*a*) that the *floors* should be impervious[1] and the corners of the rooms rounded to facilitate their being kept clean by the frequent washing down that is necessary; (*b*) that a *good light* should reach all parts of the buildings and especially the inspection room; (*c*) that the *heating* be adequate, particularly in the apartments where the men are stripped and perhaps obliged to remain waiting; (*d*) that the *doors* should open only in one direction so that those who enter are obliged to proceed only one way, i.e. from the unclean toward the clean side, by successive stages (as indicated in Fig. 26), this being secured by placing the handles of doors on one side only (Uhlenhuth and Olbrich's suggestion).

In Fig. 26 the disinfesting department is figured as a simple chamber opening into two apartments on the unclean and clean sides respectively

[1] Wooden floors should be treated as described on p. 570.

after the manner of a permanently installed steam or hot-air disinfestor. This simple arrangement may serve in small stations, but in larger ones the department constitutes a complex by itself; the disinfestation in such cases may have to be coupled with a laundry establishment, etc.

With regard to the *personnel* it is eminently desirable that the men composing it should be permanently engaged in the work of the station, otherwise there will be errors committed and a lack of continuity in the application of methodical treatment. Only efficient and trustworthy men should be members of the staff. The staff should be thoroughly instructed in the duties they have to perform, be subject to periodic inspection and control, be provided with impervious protective clothing (see p. 420), and be allowed frequent changes of garments, and adequate bathing facilities.

A Lousing Station near the Front.

The following graphic description of the working of a station in France is given by Lelean (1917, pp. 206–8) who writes:

"The organization required here may be illustrated by a brief description of a *modus operandi* which achieved marked success at the front in France. The buildings were those of a large clothing factory, which proved most suitable for the purpose. One regiment was dealt with per diem, and marched from the trenches to the premises where batches of the men were dealt with at a time. They first shed their outer clothing, which was removed on lorries to be dealt with as will be presently described. The men then passed into the old soaking-room, where there were three huge vats filled with hot water. The underclothing was thrown off and put into tubs of strong disinfectant, while the men got into the vats—ten at a time—and washed themselves thoroughly with soap. As considerations of time, space, and facilities for heating water did not permit of fresh water being provided in the vats for each lot of men, two lots had to use the same water in succession, and in the interim the vat contents had to be chlorinated to reduce the impurities to reasonable proportions. On emerging from the bath the men rubbed themselves with the lysol soft-soap lather, and then rapidly got into clean underclothing left over from the regiment treated on the preceding day and meanwhile sterilized and washed. While the men bathed, an army of women were employed in an adjacent room in hot ironing the inner seams of the men's outer clothing, into which some of the lather was subsequently rubbed. The men then donned their serge and marched off to billets. Such men as specially required it got their

hair cut and soaked their heads in the mixture of kerosene and olive oil.

"One regiment could just be run through this cleaning station in a day, and then the men had to occupy billets vacated that morning by the unit which had just relieved them in the trenches. Lack of quarters made this Box-and-Cox arrangement unavoidable. The condition of the bedding in the billet, thus in permanent occupation without an interval for treatment—even had any means of treatment been available—in due course discounted what benefit had been achieved, but it was something to know that the whole unit had at least been clean and vermin-free for an interval, however brief. There being only the one building large enough and capable of being spared for this purpose for a division of 20,000 men, it follows that continuous work at the maximum capacity only enabled each unit to be dealt with once in twenty days.

"This description serves two purposes—it indicates something of the difficulties which were experienced at the front, and something of the energy and ingenuity which were expended by our medical officers in the attempt to cope with those difficulties."

Movable Lousing Stations.

These were started at an early date in the present war, all kinds of apparatus, improvised and otherwise, being utilized. In the French army, it was soon recognized that frequent baths and disinfestation of clothing were of paramount importance, disinfestation by sulphur dioxide being chiefly employed and steam to a subsidiary degree. The transportable shower-baths introduced in the French army will presently be referred to (p. 571), these having proved of signal service. In connection with movable lousing stations the reader is referred to the description (p. 463) of the railway van disinfectors as employed in Egypt.

The published accounts of the work of disinfestation in the field are sketchy and meagre as a rule, a contrast being afforded by the description of Lelean (1917, pp. 203–6) which shows what ingenuity can do in the face of difficulties. In combating lousiness among troops in Egypt Serbian barrels were used as disinfestors (see p. 455):

Lousing an Isolated Division in the Desert.

Much organization is required so that the process shall run smoothly. To disinfest 1400 men per day the following articles are required: 80 Serbian barrels; 500 ft. length of canvas troughs; 140 shower-bath

platforms, each fitted with a petroleum tin finely perforated at the base, or, failing these, an equal number of washing basins; 1400 spare blankets; 90 lbs. each of N.C.I. Powder and Vermijelli; 14 treneh furnaees, eaeh to heat a row of 10 petroleum tins, the whole domed over with a mixture of one part ehopped straw to 8 parts elay or desert sand made into a thick paste with water in suffieient quantity and baked. Water, fuel, a mixture of petroleum and olive oil in equal parts, all three in suffieient quantity. To quote Lelean's words:

"*Ablution*: Eaeh man strips and hands in his elothing, tied up in three bundles (as shown under equivalents, p. 477) to eaeh of whieh is attaehed one of the series of four metal dises given him, and bearing the same number, while he retains the fourth dise by which he identifies his elothing when it has been deloused.

"He then soaps himself all over into a lather, after whieh he brings his kerosene tin of hot water from the furnaee and tips it into the tin over his shower-bath platform. He is allowed two quarts, and the flow can be maintained for 5 minutes if the perforations be small, while he lathers himself and is flushed elean. 140 men ean wash every 10 minutes, if the attendant at onee refills the boiling tins and replaees them on the fire. The whole 1400 men should have washed by 10.0, and the heads that are verminous should be rubbed with a mixture of equal parts of kerosene and olive oil, which may be removed the last thing the same night. Each man then wraps himself in his blankets until his elothing is dry, or may wear his greateoat until it is wanted for treatment.

"*Washing of underclothing*: 250 men, standing alternately on opposite sides, ean wash their underelothing at one time in the troughs provided. Hot water is available as soon as the ablution is finished. The last bateh of underelothing should be sterilized by 10.0 and all should be washed by 1.0, if each man be allowed a half-hour. It is then dried, and, before being put on, is dusted with $\frac{1}{2}$ oz. of N.C.I., while vermijelli should be smeared on the outer seams. Greateoats and blankets should be handed in before the elean underelothing is put on.

"*Treatment of outer clothing*: After the men have had their dinners, the outer elothing should be dry and put on, after smearing the inner seams with 1 oz. of vermijelli per man.

"By 4.40 the whole elothing and one blanket per man should be clean and dry. The detaehment then draws a clean extra blanket from the reserve, and returns to its quarters in time for tea.

"Subsequently the blankets left behind are treated by 4.40, and then dried in readiness for issue to the detaehment due on the following day.

"It only remains to mention that when water is scarce it may be re-used after precipitation by alum and sterilization of the syphoned-off clear layer by addition of sufficient bleaching powder to give a chlorine reaction (with test-box supplied) after 30 minutes."

The Louse Problem under adverse conditions.

The various conditions under which soldiers may be placed and the increasing difficulties that arise in lousing men as the opportunities for maintaining personal cleanliness decrease have already been referred to (p. 559). As an example of how a single adverse factor may operate in vitiating otherwise well intended preventive measures I would note an instance where the absence only of laundry facilities among troops encamped in England led to their remaining verminous under otherwise favourable conditions. I quote the instance on the authority of the medical officer who was in charge of the men concerned:

Although the men were periodically disinfested and bathed, it was found that they continually became reinfested, the cause being finally traced to their underclothes. There was no definite organization to deal with the washing of undergarments; they were distributed to private persons, soldiers' relatives and others, to be dealt with. Consequently some men's clothing was frequently changed whilst that of others was changed at longer intervals depending upon when the men received their effects returned from the laundry. The result was that there were always *some unclean men among the clean, the unclean reinfesting the clean.* It was not until a laundry was established at or near the camp, so that all the men were not only loused but received clean underclothes simultaneously, that the men, as a whole, could be kept free from vermin. This instance affords an excellent object lesson as to the futility of incomplete preventive measures, it being *essential not to allow a single man to remain unclean when living in close association with the clean,* for the unclean will invariably reinfest the clean.

Another medical officer informed me of his experiences in France where he failed in spite of every effort to keep his men free from pediculosis and scabies until, after innumerable difficulties, he was able to bring it about that unclean men posted to his unit from other places were inspected and treated *before* they were allowed to mix with his men. By forcing through this common sense measure he reduced the incidence of these complaints among the men by 80 %.

Where men cannot be supplied with an adequate change of clothing,

disinfestors are insufficiently numerous or lacking, washing facilities are meagre or absent, and there are few opportunities for undressing, the difficulties of dealing with lousiness are very great, and all that can be accomplished, in the present state of our knowledge, is merely to mitigate the evil by palliative measures.

Palliative Measures.

These consist (*a*) in the mechanical removal of lice and nits from the person and clothing, (*b*) the application of dry or moist heat to clothing by some of the simpler methods herein described, and (*c*) the use of insecticides, one or all of these procedures being employed, as follows:

(*a*) Hand-picking and combing of the head with a heated comb, cutting or shaving the hair of the head and body; frequently brushing, beating and hand-picking the infested clothes, doing this in the open air, preferably on sunny days, and turning them inside out and paying special attention to the seams and folds whilst so treating them; if possible employ periodic dry storage of infested clothes (pp. 423–7). The interchange of articles of apparel, blankets, etc., and the overcrowding of individuals greatly favour the dissemination of lice.

(*b*) Infested clothing, when valueless, may be burnt. Singeing, sun-baking and ironing of infested effects may be practised; they may be wrapped around tins containing boiling brine, or baking ovens or substitutes for these may be employed (pp. 435–7). Any piece of heated iron or even hot stones from a camp fire, or holding the clothes very close to a hot fire will serve to kill and dislodge many lice. Underclothes especially may be treated by immersion for a moment in boiling water, or water that is near boiling-point; clothing can be passed athwart the steam jet issuing from the nozzle of a kettle, or exposed over vessels of boiling water whilst enclosed in boxes or barrels (pp. 454–459).

(*c*) Insecticide solutions[1] may be used for the immersion, impregnation or spraying of infested clothes that are in use, or be applied to the body and head. Insecticides may be used as powders dusted in the clothing, or these, when removed, can be exposed to the action of insecticide vapours when enclosed in air-tight containers.

Although called palliative, these measures, if combined and thoroughly carried out, may give excellent results provided that the anti-louse campaign is kept up continuously. If imperfectly carried out, the measures at least mitigate the evil. The use of insecticides as a whole,

[1] Specified on p. 575.

either upon the person, or upon clothing that is being worn, is always a confession that men cannot be kept clean by direct means, through there being a flaw in the barrier of preventive measures. This flaw may be beyond the control of the medical officer and is commonly brought about by unclean men or effects escaping attention in various ways and serving to transmit vermin.

Supplementary Disinfestation.

When a unit evacuates *barracks or hutments*, all blankets and bedding left behind should be treated before reissue, the apartments should be thoroughly cleaned, the floors being sprayed or scrubbed down with insecticide solution or treated with a steam jet.

In *billets* the floors should be similarly treated, and the walls, when possible, whitewashed; special attention should be given to cracks between the floor-boards. As suggested by Peacock (*MS.* I. 1918), it is well to post up a notice in billets for the men to read, the notice stating briefly the essential facts which a soldier should know regarding the methods of combating lousiness.

Railway carriages, under ordinary circumstances, may be disinfested by scrubbing down all washable parts with insecticide solutions, afterwards drying off the iron work to prevent its rusting. Vans, and the like, may be adequately treated with a steam jet supplied from the engine. Benzine vapour has been used in France for destroying lice in better class carriages but it is too expensive a procedure to employ on a large scale (p. 522, No. 370). A German newspaper, published during the war, illustrates what is doubtless the largest disinfector ever built, the structure being capable of admitting a whole railway carriage. The disinfector consists of a cylindrical steel tunnel into which the carriage is rolled, circular doors, sliding on cross rails, being run across the ends and bolted as in large steam disinfectors. Whether such monster disinfectors are of practical utility or not cannot be stated; they savour rather of advertisement.

Transport waggons may be washed down or sprayed with insecticide solutions or treated with a steam jet.

Effects that suffer from exposure to heat, especially rubber (including ground-sheets and macintoshes) and leather (unaffected by dry heat at ca. 65° C.) may be immersed in insecticide solutions and afterwards hung up to drain and dry.

Furs should be disinfested by dry heat (55–65° C.) or exposure to CS_2 vapour (see p. 525, No. 384).

Baths in connection with Disinfestation Stations.

The relation of the bath to the general procedure of disinfesting men has already been discussed (pp. 560 et seq.). A few remarks are here interposed regarding bathing arrangements. The reader is referred to p. 567 for a description of a simple method employed in Egypt under desert conditions, each man being allowed 20 minutes for his ablutions, including 2 minutes under the shower. For heating bath water in a home-camp, Copeman (1915, p. 247) employed 200 gallon galvanized iron tanks resting on bricks set with puddled clay over a trench in which a fire was made, the smoke escaping through a chimney placed at the end of the trench; the water boiled after an hour and was carried in buckets from the tank to tubs placed in a tent.

Bath tubs for use by single persons will usually be used in private institutions. Where facilities are limited, the verminous subject may remove his underclothes in the empty tub, boiling water being thereafter poured upon them to kill the lice; the clothes can then be transferred to a receptacle and the bathing of the individual proceeded with.

Bath tubs of graded sizes, arranged to fit into each other so as to occupy little space, have been used in a limited way in the armies at war, especially for the wounded. They cannot be used on a large scale because of transportation difficulties and the amount of water required; some of them are provided with a small portable boiler.

Large tubs or soaking vats in which several men can bathe at a time have been used in connection with stations, especially where these have been established in disused factories where they are at times found ready to hand. The vats may be of wood or brick and cement, the latter measuring say $10 \times 6 \times 2$ feet (deep) are filled only up to a depth of about a foot with warm water to facilitate its frequent renewal. The men soak in the vats before soaping themselves down and seeking the shower-bath, hence the water in the vats may become rapidly dirty (Moor and Cooper, 1918, pp. 92–96).

Shower-baths have largely solved the difficulties due to transport and limited water-supply in dealing with large numbers of men that have to be bathed at frequent intervals. Excellent movable shower-baths were devised early in the war for use in the French army. In some cases the water is carried in barrels on railway trucks stationed at sidings, at other times the barrels are conveyed on carts, in both cases the showers projecting over the sides along which the men stand on grated platforms whilst performing their ablutions in the open, when the weather

permits. Showers that are rapidly erected in large tents or enclosures also came into general use, it being found that the process of bathing is thereby accelerated whilst but a modicum of hot water is required. Portable boilers supply hot water on the geyser system to the overhead pipes which feed the showers that are ranged in lines and supported on a light iron framework. Similarly, in Germany, batteries of barrels serving as a reservoir, are mounted on wooden platforms about 10 feet high, pipes proceeding thence to supply rows of showers to bathers standing on slatted gangways beneath. According to Moor and Cooper (1918, p. 92) the French shower-bath, provided with 12 sprays, uses but $\frac{7}{8}$ of a gallon of water in 2 minutes, being most economical since but 1 cwt. of fuel is consumed in heating the water for a period of 10 hours, whilst 100 men can bathe per hour when the men are moved along rapidly. The necessity of practising economy in the use of water may be very great when water is only supplied from wells and small ponds; it is better, therefore, where larger bodies of men have to be bathed, that plenty of water should be obtainable from a stream, at least 2 gallons having to be reckoned per head. To supply one bath per man every two weeks, the bathing of a division (20,000) necessitates bathing 150 men per hour for 10 hours each day. The plant required may have to deal with 1000 men a day or 100 an hour to allow for small additional units that may need periodic baths.

Bath-trains, illustrations of which I have seen emanating from German journals, may be composed of: an engine, a truck carrying a water-cistern, 3 freight vans with baths (the first for officers), a carriage for the storage of towels, soap, etc., and a carriage for housing the personnel in charge. The steam from the engine heats the water. The water-cistern consists of a metal cylinder resting lengthwise on the truck next to the engine; it corresponds almost in size to a freight van and is provided with a float and large indicator with semicircular scale to register the amount of water in the cistern. The bathing trucks are painted white inside, the floor is slatted, and a slatted bench runs along one side. Large doors serve to link the two vans for the men corridor-wise. The officers' van contains fewer showers than the men's vans, these being supplied with 16 showers each fed by a pipe running lengthwise beneath the ceiling of the van; the showers branch off at right angles towards the sides of the van so as to leave adequate space between the bathers. The men undress in ordinary railway carriages drawn up alongside the bath-train. The cistern is prominently marked "Badezug," and the several vans "Badewagen" in white letters.

V. General Summary and Practical Recommendations.

As a first step in combating lousiness it is essential to teach men what lice are, and to tell them of the harm that lice may do. Having impressed this upon them, they should learn about the simple ways of mitigating the scourge which any intelligent person may employ. The words of an unknown Englishman, written 450 years ago, still hold true for combating the evil:

"The best is for to wasshe the oftetimes, and to chaunge oftentymes clene lynen[1]."

This one sentence might be regarded as a summary and practical conclusion to all that the foregoing pages contain but for the circumstance that many persons are so placed that they do not wash frequently or do not change their undergarments as often as they should, because of circumstances over which they may have no control.

Unremitting attention is required in the care of the body, head and clothing (pp. 418–420). Infestation may be prevented by protective clothing, by avoiding contact with the verminous and overcrowding of individuals some of whom may be unclean, by good ventilation in buildings, by frequent inspection whereby the evil, if discovered, may be checked at the start (pp. 420–423).

The plan of procedure to be pursued in combating lousiness among troops and others is fully dealt with on pp. 559-565 and need not be recapitulated here. Suffice it to say that failing any other means, man may rid himself of vermin by the simple mechanical methods that animals and primitive peoples employ, and it is expedient that he should learn this if his defensive instinct is dead or dormant. Better placed than the animal, he can use razor and fine comb (in dialect "Scotch louse-trap") and can temporarily or otherwise discard the clothing that corresponds to the infested fur of which animals cannot divest themselves.

When seeking to destroy lice one should not be deceived by the feigned appearances of death that they may assume temporarily (p. 428). Both lice and nits are readily killed by a moderate degree of dry heat, by 55° C. in 5 minutes, or by 65–70° C. in 1 minute, but in the practice of disinfestation by hot air the exposure period should be lengthened say to 15 minutes at 60–65° C. to allow for the penetration of the heat into the infested clothing. When immersed in water at 70° C., they are killed in 5 seconds, but in practice infested articles should be immersed a

[1] See reference, p. 417.

minute or two at this temperature or 10 minutes at 55° C. They are killed instantly by moist heat at 80° C. or over. In a steam disinfestor that has been properly packed and managed the exposure period need not usually exceed 15 minutes (pp. 429–435).

The various forms of apparatus employed for the destruction of vermin by dry heat and steam are described, leading up from the simplest to the more complicated. Special stress is laid on improvised methods devised by medical officers from materials at hand, no apparatus being available, or when many of the forms of apparatus employed successfully in peace times had for various reasons failed to meet the exigencies of war (pp. 435–450, 454–466). The main source of failure in the regular disinfecting machines is due to their being primarily designed to destroy the causative agents of infective diseases according to bacteriological standards, coupled with their altogether too small size. The number of articles that require to be treated when lice have to be destroyed on the clothing of vast numbers of men demands the use of larger apparatus.

For louse destruction on a large scale, but two methods commend themselves, i.e. hot-air and steam disinfestation. Huts built of cheap materials, according to some of the plans herein described, may be used for this purpose (pp. 441–450, 459–461). The huts can be built of different sizes to meet various requirements. Railway vans may be used, the number of these being multiplied in accordance as they are wanted (pp. 461–465).

Stress is laid upon the need of standardizing the load of effects introduced into the disinfestor or disinfector. The effect of steam and hot-air disinfestation on clothing is discussed and the advantages of hot air over steam stated. Given the choice, either of these means are greatly to be preferred to sulphur fumigation (pp. 474–481).

The methods of recording the temperature in the disinfector chamber are briefly considered and a simple and useful method employed in France described (p. 481). Common causes of failure in disinfestation are pointed out in some detail because so frequently recurring and vitiating the results obtained in practice (p. 482).

Insecticides and remedies employed against lice, together with their mode of action and application, are considered. It is concluded that so-called repellants exert their chief effect on lice by virtue of their being primarily insecticides; they do not prevent hungry lice from biting man.

Surveying the list of remedies for lousiness and the evidence in favour of their usage (pp. 519–558, Nos. 364–474) supplied by experiments

and practical experience, a number may be chosen as having given satisfaction. Details concerning the remedies and their mode of application will be found by turning back to the *reference numbers* hereafter cited in brackets. The remedies and methods that appear most useful are marked with an asterisk (*).

Remedies against head-lice: Acetic acid is of great use as an aid to the removal of nits (364). Alcohol, with or without the addition of camphor (373). Benzine (370) and Xylol (474, also as an ointment), but both are highly inflammable. Carbolic acid solution* (375), also as pomade and with oil (378–9). Chloroform-water (388). Sublimate vinegar* (414), Calomel pomade (419). Oleate of Mercury and Ether (420), to be used with caution. Oil of Sassafras (441), objectionable because of its smell and that it soils pillows, etc. Oil of Turpentine* (Ol. tereb. rect. 442), smell agreeable and does not soil. Balsam of Peru ointment alone (446, where impetigo present), or with sulphur (447). Petrol and Methylated Spirit (449). Petroleum* alone (450, a household remedy) or with olive oil (451), an objection is the smell. Petroleum-vinegar (456). Veratrine ointment ($\frac{1}{2}$ %, 460). Staveacre oil or ointment (463). Treatment in most cases has to be repeated because of the *nits* remaining unaffected.

Remedies against lice on clothing and on the body: (1) Acting by their vapour on effects exposed in closed spaces are Benzine (370), Carbon bisulphide (384, for furs especially) and Xylol (474), but all very inflammable. Creolin* (391), not inflammable, non-toxic, but odour disliked. Hydrocyanic acid gas (402), highly toxic but penetrates fast and evaporates quickly, therefore it might be used with safeguards. Sulphur dioxide is not recommended for reasons specified (465). (2) Acting chiefly by contact, the following *Insecticide solutions*, 1–2 %, are recommended for washing down floors, steeping infested clothes, boots and other leather objects (for 15 minutes or more), and for use by men when bathing, being combined with soft soap to aid in cleansing: Cresol-soap* (395), Cresol-petroleum-soap* (396), Lysol-soap* (406), also 454–5, or Crude Carbolic acid solution*[1]. These soap preparations will doubtless act as well as the much advertised Vermijelli (473); they can be similarly applied.

For spraying or application to the skin or body hair when infested: Petroleum (450, with care), also applied as an ointment. For the treatment of infested clothing when being worn, and supposedly to repel lice: Crude Naphthaline and Soft Soap*, ironed into the seams which have been folded back after smearing the mixture into them; the

[1] See p. 582, note to Bacot and Lloyd.

mixture may be combined with diatomaceous earth as a vehicle (429 (*g*) and (*h*)); naphthaline sachets are probably of little use (see discussion under 423–8). Oils of Birch-tar (437), eucalyptus (438), turpentine (442) and Tar preparations (466) appear worthy of further trial for the purpose of impregnating clothing. Ammoniated Mercury as a powder (410). Few of the foregoing remedies affect the *nits* and unless the application is thorough nits may survive in all cases.

Remedies against crab-lice: Absolute alcohol* (366, applied as a spray), Benzine ointment (370), Chloroform-water should be tried (387–8). White precipitate ointment* (409), Sublimate-vinegar (414), Calomel pomade (419), Oleate of Mercury and Ether (420), Red or Yellow Oxide of Mercury ointment (421–2). Mercurial preparations should always be used with caution. Some of the remedies given under head-lice should be tried. Treatment may have to be repeated because *nits* may survive, unless shaving is very completely performed.

When lice occur beneath bandages which cannot be removed, Naphthaline, Oils of Eucalyptus or Turpentine appear the most suitable for application. No final opinion can be given as to the usefulness of the various kinds of impregnated underwear that have been supplied by private agencies and various firms for the use of soldiers; it will probably be found that the cost and labour involved are not proportionate to the results attained.

To answer practical requirements, a remedy should be cheap and easily obtainable, not be injurious to man, not soil clothing, be readily manipulated under adverse conditions, not be too volatile and inflammable. These requirements are answered by some of the remedies above-mentioned. For the armies in the field a number of the remedies suggested may not be procurable but some of those in the foregoing list should be obtainable. What Buchanan (1917, p. 21) writes is very true: "It is noteworthy that few of the many panaceas against lice which were put out at the beginning of the war have stood the test of time and practical experience. Nearly always one came back to current steam for clothing and blankets, or to cresol and petrol emulsions."

It appears desirable that steps should be taken by Government to prevent soldiers and their relatives from being victimized by unscrupulous firms who flood the market with purported remedies against lice which may be injurious, and are usually valueless.

RECOMMENDATIONS.

1. Soldiers should be inspected once a week under all circumstances, i.e. when on active service or otherwise engaged. The examination should be made at the same time as that for scabies.

2. Men who are found to be verminous should be disinfested as soon as possible.

3. All soldiers should receive a bath once a week or at least once in two weeks, the bath being followed by a change of underwear.

4. Where men are prone to become verminous, disinfestation should be practised every two weeks.

5. Disinfestation should be applied to all of the men who live in close association, none being allowed to escape the process. Every article of clothing pertaining to each man, including his greatcoat, blankets and pack, should receive treatment. Various articles which are the soldier's personal property may harbour vermin, and it should always be remembered that not only crab-lice but also *Pediculus* may infest the hair over different parts of a man's body.

6. Bathing should be controlled to see that it is efficiently carried out, the men being inspected after the bath and before being allowed to dress.

7. The larger the number of men who are loused at one time the better since there will be fewer verminous companions about through contact with whom they may subsequently become re-infested.

8. As far as circumstances will permit, the cleaned men should be kept apart from the unclean.

9. Soldiers proceeding to the front or returning thence should in each case be examined before they are allowed to mix with other men. A single lousy individual may infest many others with whom he associates.

10. The hair should be kept cropped short, especially at the sides and back of the head.

11. The personnel employed in lousing men should be permanent, specially instructed, and trustworthy, to ensure efficiency and continuity in the established methods of treatment.

12. The personnel should have unlimited facilities for bathing, be subject to inspection and control once a week (as for scabies), and keep their hair close cropped. They should wear protective clothing whilst engaged in their duties.

13. The only thoroughly reliable means of destroying lice are by hot air and steam. Sulphur dioxide is unreliable, and *insecticides as ordinarily applied to men are merely palliative because they fail to destroy the nits.*

VI. SUPPLEMENTARY NOTES.

The following notes relate to various references that I have come across in my reading concerning lice. This appears the most convenient way of placing them so as not to disarrange the text whilst going through the press and to supplement what has already been published.

Phthirophagi (note to p. 184). Herodotus and Strabo in Pontus speak of men that feed on lice (Moffett, ed. 1658, p. 1093).

Hearne (1795, p. 325), writing of the Northern Indians (Arctic America), records: "Their clothing, which chiefly consists of deer skins in the hair, makes them very subject to be lousy, but that is so far from being thought a disgrace, that the best among them amuse themselves with catching and eating these vermin; of which they are so fond, that the produce of a lousy head or garment affords them not only pleasing amusement, but a delicious repast. My old guide, Matonabbee, was so remarkably fond of these little vermin, that he frequently set five or six of his strapping wives to work to louse their hairy deer skin shifts, the produce of which being always very considerable, he eagerly received with both hands, and licked them in as fast, and with as good a grace, as any European epicure."..."The Southern Indians and Esquimaux are equally fond of these vermin."

*

Uncleanliness and lousiness in Ireland, Prisons and Armies. "All Ireland is noted for this, that it swarms almost with Lice. But that this proceeds from the beastliness of the people, and want of cleanly women to wash them is manifest, because the English that are more careful to dress themselves, changing and washing their shirts often, having inhabited so long in Ireland, have escaped that plague. Hence it is that Armies and Prisons are so full of Lice" (Moffett, ed. 1658, p. 1092). This bears on the prevalence of typhus in Ireland (vide p. 44).

*

The wandering of lice from the dying (note to pp. 96–97). In those in whom the sweat "grows bitter (as we find in those that are dying, or troubled with the jaundice) they forsake their stations and creep from the body into the pillows that are under them." Their wandering is a sign of approaching death. Referring to jaundice, it is worth noting that *bile* is one of the remedies for lice given by older authors (Moffett, ed. 1658, p. 1091).

*

Influence of climate on lice (note to p. 90). "Know, Sancho, that the Spaniards and those who embark at Cadiz to go to the East Indies, have for one of the signs by which they learn that they have passed the equinoctial line of which I have spoken, that on all who are in the ship the lice die off, without one remaining, nor in all the vessel is any to be found, if they give his weight in gold for him" (Cervantes, 1615, *Don Quixote*, Part II, Chapter 29).

In H. E. Watts' translation (1895, vol. III. p. 317, London, Adam and Charles Black) occurs the following footnote bearing on this passage:

"The authority for this remarkable piece of natural history, which subsequent investigators have not confirmed, is Abraham Ortelius in his *Theatrum Orbis terrarum*, of which an edition in Spanish was printed in Antwerp in 1612. He, however, declares that it was immediately after passing the Azores on the voyage westward, that navigators found themselves freed of fleas, bugs, and every kind of personal vermin."

In the 1592 edition of Ortelius, printed by Plantin in Antwerp, of which I possess a copy, the following passage occurs on p. 15:

"Mirandum autem quiddam de harum insularum solo, aut caelo, ne dicam genio, hoc accepi: Soluentes vtpote ex nostro hemisphaerio versus Americam, aut nouum, vt vocant, Orbem, quàm primùm Açores à tergo reliquerint, continuò liberari à cimicibus pulicibusque, atque omni pediculorum homines infestantium genere, quod statim, praeternauigatis his insulis, moritur, extinguiturque."

It is interesting to note that Moffett, writing in 1590, mentions this (vide ed. 1634, p. 262) and refers the disappearance of lice to "caloris inter Tropicos."

*

The lousing room of former times. "He went into the lousing Room, and turned a little Board that hung at the Door, on which was written, *One is lousing*, that no other might go in until he had done." This passage is taken from Stevens' translation of Quevedo made in 1707. The original work in Spanish was written about 1608 and first published in 1626. Dr Shipley kindly lent me a copy of the edition illustrated by Vierge in which the "little Board" bears the two words "espulgador hay." Although *pulga* stands for flea in Spanish, Dr Shipley informs me that Neumann and Baretti give espulgador the primary meaning of a louser. Therefore, translated, the words mean "*there is a louser.*"

Quevedo-Villegas, F. (eds. 1707, 1892), *Pablo de Segovia, the Spanish Sharper.* [Transl. by J. Stevens, 1707, in Quevedo's Compl. Wks. 1709, p. 229.] See also

the fol. ed. illustrated by Daniel Vierge. London: T. Fisher Unwin, 1892. [In reference to the word *lousing*, see pp. 144, 164.]

*

Cases of Melanodermia due to Pediculus humanus. Greenhow (1864, p. 226) describes a case: Woman, tramp, aged 65, admitted 3. VI. 1863 to Middlesex Hospital, in a very dirty state and swarming with vermin. Her face became tawny about 2 years previously and some months later it became darker and still later her chest and back became brown. On admission: face yellow, chest and back deeply bronzed, thighs lighter, legs and feet scarcely tinged. She greatly improved in hospital. On 24 Aug. numerous small patches of normal coloured skin observable on chest, bronzing elsewhere fading, the face no longer yellow, hands normal. "Even the darkest portion of the surface has, on close inspection, a mottled appearance, being interspersed with minute spaces of normal skin." She was evidently recovering from the melanodermia.

Greenhow (1876, p. 44) records the following case: Man, scavenger, aged 60, admitted to Middlesex Hospital 24. XI. 1875; hard drinker, dirty and swarming with head and body lice. General body-surface dirty bronze coloured, skin rough; the epidermis, on being scratched, was raised in furfuraceous scales. Bronzing deepest on sides and back of neck, in axillae, on hips, loins, abdomen and chest; less marked on the face, hands, arms and legs, at sides of trunk and back of thorax; and, across the shoulders, a broad band, extending down to 7th dorsal vertebra, was comparatively not tinged; areolae about nipples, penis and especially scrotum almost black; small irregular patches of normal skin on back of neck; mole-like specks on arms and hands; lips with faint dark lines, light brown mottling of mucous membrane of cheeks.

The patient was given warm alkaline baths, being freely soaped whilst in the bath. Improvement (14. I. 1876): bronzing all over still very pronounced on front of body though much paler than on admission, penis and scrotum still almost black; patches of normal skin at back of neck larger. Colour of face, hands, backs of shoulders practically normal in colour.

Such extreme cases as the two foregoing are rare in England but appear to be commoner in Germany (Vogt's "Vagabondenkrankheit").

*

A poet's contribution to the subject, proving that Robert Burns (1759–1796) had knowledge of the louse's ways and haunts and of how to circumvent the "blastit wonner." The short glossary was compiled from a Dialect Dictionary.

TO A LOUSE, on seeing one on a lady's bonnet, at church.

Ha! whare ye gaun, ye crowlin' ferlie? *ferlie* = a wonder
Your impudence protects you sairly:
I canna say but ye strunt rarely,
Owre gauze and laee;
Though faith! I fear ye dine but sparely
On sic a place.

Ye ugly, creepin', blastit wonner,
Detested, shunn'd by saunt an' sinner,
How daur ye set your fit upon her,
Sae fine a lady!
Gae somewhere else and seek your dinner,
On some poor body.

Swith, in some beggar's haffet squattle. *haffet* = temples
There you may creep, and sprawl, and sprattle *squattle* = to squat or settle down
Wi' ither kindred, jumpin' cattle, *sprattle* = scramble
In shoals and nations;
Whare horn or bane ne'er dare unsettle *horn* = comb for the hair
Your thick plantations. *bane* = poison

Now haud ye there, ye're out o' sight,
Below the fatt'rels, snug an' tight; *fatt'rels* = folds
Na, faith ye yet! ye'll no be right
Till ye've got on it,
The vera tapmost tow'ring height
O' Miss's bonnet.

My sooth! right bauld ye set your nose out,
As plump and gray as ony grozet; *grozet* = gooseberry
Oh for some rank mercurial rozet, *rozet* = resin
Or fell red smeddum, *smeddum* = a powder
I'd gie you sic a hearty doze o't,
Wad dress your droddum! *droddum* = breeeh

I wad na been surprised to spy
You on an auld wife's flannen toy;
Or aiblins some bit duddie boy, *aiblins* = possibly
On's wylieeoat; *duddie* = wooden dish with two ears
But Miss's fine Lunardi! fie! *wyliecoat* = undervest or night shirt
How daur ye do't? *Lunardi:* the famous aeronaut. Bonnets were called after him in 1785.

O Jenny, dinna toss your head,
An' set your beauties a' abread!
Ye little ken what cursed speed
The beastie's makin'!
Thae winks and finger-ends, I dread,
Are notice takin'!

Oh! wad some power the giftie gie us
To see oursels as others see us!
It wad frae mony a blunder free us
And foolish notion:
What airs in dress an' gait wad lea'e us,
And even devotion!

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Note (whilst in press): The authors describe experiments on *corporis* nits immersed in different strengths of insecticide solutions. (1) *Lysol-soap* in 1·5–2 % solution killed 100 % in 5′; (2) *Crésol-soap* in 2 % solution killed 97 % in 5′, 100 % in 20′, whilst 0·5 % solution killed 11 % in 5′, 65 % in 20′ and 100 % in 150′. These tests were made at 9–18° C., but at 0° C. the exposure should be slightly lengthened. As in bacterial disinfection, the presence of organic impurities may modify the potency of the solution. The experiments, in the main, confirm what is stated in my text, pp. 528, 530, 575, q.v. Consult the original.

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cited by Brumpt. The reference is given by Dubreuilh and Beille.] **B.D.**

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Miessner, H. and Lange, W. (13. IX. 1917), Desinfektion mit heisser Pressluft in dem Vondran'schen Apparat. *Arch. f. wiss. u. prakt. Tierheilk.*, Berlin, XLIII. 329–365, 5 figs. **K.**

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—— **(1658),** *The theatre of insects: or, lesser living creatures*, etc. 9 + 889–1130 pp. with 3 last of figs. Appended *The History of Four-footed Beasts and Serpents*. Ed. Topsell. London. [Transl. by J. R. of Moffett, 1634, q.v. pp. 1090–4, 1123.] **G.K.**

Biographical note: Thos. Moffett, born 1553, died 1604. M.A., Cantab. 1576, M.D. Basle 1578, and Cambridge 1582, by incorporation. Resided in Ipswich, London, and Wiltshire, M.P. for Wilton 1597. The MS. of his Theatre of Insects was completed in 1590 (Sloane MS. 4014), the work being published posthumously, first in Latin (1634), then in English (1658). His name variously spelt: Moufet, Muffet, Moufetius. See *Dict. Nat. Biogr.* XXXVIII. 101.

Moor, C. G. and Cooper, E. A. (1918). *Field Sanitation*, 220 pp. illustrated. London: Baillière, Tindall and Cox. [Brief account of lice pp. 53–56.] **O.**

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Nuttall, G. H. F. (19. XI. 1917), Bibliography of *Pediculus* and *Phthirus*. *Parasitology*, X. 1–42. **Bibl.**

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Pizzini, L. (1. V. 1917), I pidocchi nella epidemiologia della meningite cerebro-spinale epidemica. *Policlinico*, Rome, XXIV. 212–218. Abstract in *Rev. Appl. Ent.* ser. B. v. 152. [Regards lice as vectors. More evidence required.] **D.**

Ray, J. (1710), *Historia Insectorum.* Opus posthumum Jussu Regiae Societatis Londinensis Editum. Londini: A. & J. Churchill. XV + 400 pp. [p. 8, *Pediculus ferus,* "nos Angli Crab-louse dicimus"; brief description, refers to "*Pediculus vulgaris.*"] **H.**

Rocha-Lima, H. da (30. X. 1917), Klinik und Aetiologie der sogen. "Wolhynischen Fiebers," etc. *München. med. Wochenschr.* LXIV. 1422–6, 3 figs. Abstr. *Rev. Appl. Ent.* ser. B. VI. 58. [Reiterates his statements that *Rickettsia prowazeki* is the cause of typhus; it is an intracellular parasite of the louse, whereas "*R. pediculi*" lies *on* the epithelial cells and in the lumen of the insect's midgut as seen in sections but not in smears.] **D.**

Sharp, D. (1899), *Insects, Part II. Cambridge Nat. Hist.* London: Macmillan. [pp. 599–601, Anoplura, Pediculidae, or lice. A brief account with 2 figs. from Piaget and Graber.] **G.**

Sikora, H. (V. 1917), Ueber Anpassung der Läuse an ihre Umgebung. *Arch. f. Schiffs- u. Tropen-Hyg.* XXI. 172–3. [Lice kept in the light and dark on white, gray and black backgrounds became correspondingly pigmented, irrespective of light. Hermaphroditism (?) observed. Preliminary note.] **B.**

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Werner, H. and Wiese, O. (IV. 1917). Die Uebertragung von Rekurrenspirochaeten durch Kopfläuse. *Arch. f. Schiffs- u. Trop.-Hyg.* XXI. 139. [Note of 25 lines. Of eleven *capitis* fed on relapsing fever patient in fever two showed many spirochaetes in coelomic fluid after 8 days.] **D.**

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Correction: pp. 286–7, read *asper* in place of *aspcrus*.

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